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THE TECH ENGINEERING NEWS

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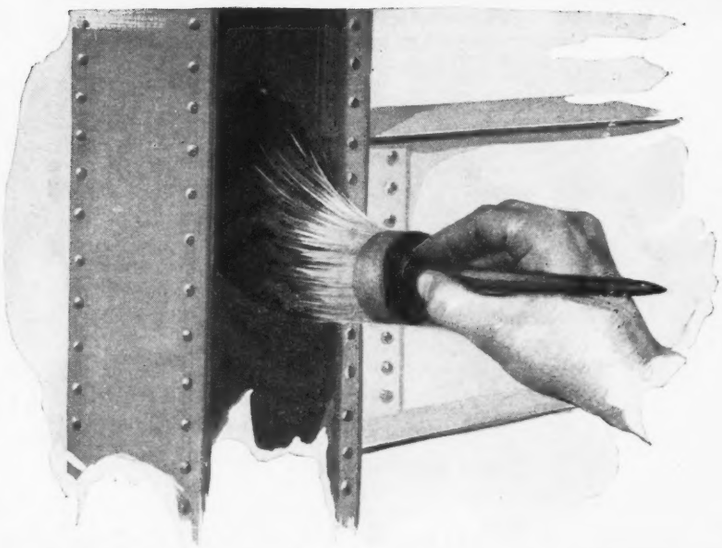
JUNE, 1923

VOL. IV MASSACHUSETTS INSTITUTE OF TECHNOLOGY NO. 3



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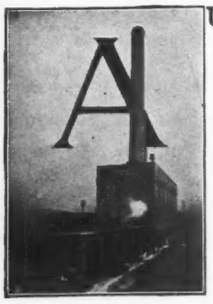

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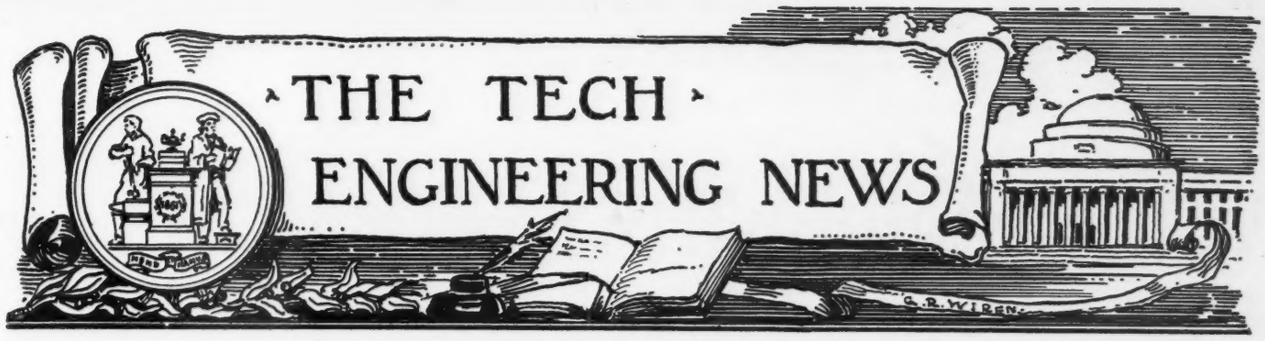

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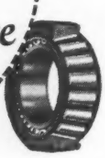

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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE ALUMNI AND UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME IV JUNE, 1923 NUMBER 3

THE UNITY OF SCIENCE AND RELIGION

By DR. A. A. BLANCHARD, '98

Associate Professor of Chemistry, Massachusetts Institute of Technology

Of all the mysteries of religion and science, man has always been to himself the greatest mystery. Whence came we, whence go we, and what are we while we are here? We are beings that are capable of experiencing sensations and feeling emotions. We recognize five senses, sight, hearing, taste, touch, and smell. By these we receive certain sensations which we interpret as indicating a world of material things about us. It is the function of science to interpret these sensations, and science has given us a very definite picture of the material world.

Definite as is this picture of the material world, we must still admit that it is only an interpretation of the sensations. We admit that often our sensations are very deceptive, and we find our consciousness sometimes inclined to doubt the material world. Our emotions exist just as certainly as do our sensations. Emotions are less easy to comprehend than sensations. They are often stimulated by the sensations, it is true, but they are something quite apart from mere sensation, something that is fundamentally a manifestation of our real selves. It is the function of religion to interpret the emotions. Our emotions are far less subject to exact definition than the sensations, and the interpretation that religion furnishes of the emotions is a far less definite and precise a picture. Nevertheless the only things of which we human beings are absolutely certain is our consciousness, and its ability to feel sensations and emotions, and, if anything, the emotions are more real than the sensations. Religion, then, is even more real than science, even if it is less susceptible to exact formulation.

Bigotry is not confined to religion. The man who thinks himself a scientist, and imagines that the whole world is embraced in his interpretation of his physical sensations, is a far worse bigot than the religious bigot.

Certain persons have claimed that religion and science are antagonistic.

Cynics have often remarked to the effect that God hates a well meaning fool more than he hates a rascal. Cynical as this remark is we nevertheless appreciate its force. The idealist who is not practical must be classified as a well meaning fool, but the practical man who does not have idealism does not need to be hated by God; he cannot avoid hating himself. It is of the idealism of science that I am to talk to you and the topic is "The Unity of Science and Religion." The scientist who fails to see behind the marvels of the universe some infinite power which is the source of natural laws must be lacking in idealism; and the religious man who disregards the teachings of science builds without a foundation. Science then is nothing without religion and religion without science is nothing. The two are inseparable, both parts of the same thing — a thing which has not been named but which deals with the destiny of mankind.

This paper is presented by a scientific man who feels that he is deeply religious, but since his version of the subject will be regarded as the scientific version, it may be well to explain what a scientist is. All people who have senses of perception and acquire useful knowledge through these senses are scientists. Even a baby who has just learned to crawl and seeing an attractive shiny object across the room goes to it and reaches up its hand is a scientist. The object is a stove with a fire inside and the baby feels a sensation of pain. It withdraws its hand in terror and bewilderment; it has had a new experience which it does not understand; it has a vague suspicion that the stove has something to do with it, but it is not certain and anyway it knows the stove looks attractive; so again it lifts its hand and touches the stove, the sensation is repeated, and now the baby knows that the stove causes pain, and should not be touched. All men who connect up their experiences with events that preceded them in the relation of cause and effect and retain the knowledge so gained to guide their future conduct are scientists. The trained scientist differs from other men simply in the degree to which he has trained himself to observe accurately, to trace back to the cause from the effect, and to so classify the knowledge he gains as to make it most available for the benefit of the world.

Some have tried to suppress the study of evolution because the conclusions from that study are in contradiction to what they think certain words of the Bible mean. What an egregious conceit, — that one's personal understanding of the Bible words is of weight against logical scientific conclusions, — that our Bible, even if it did contradict the evidence of evolution, should necessarily be true for everyone. Our Bible is the written record of only one of the world's great religions, and its beautiful teachings are very imperfectly lived in the daily lives of even that minority of the population which professes to accept it as a guide. This is one kind of bigotry, — to insist that one's individual interpretation of the statements of the particular holy book which the accident of parentage and environment led him to accept must be received as truth by others than himself, — that others shall give up their own conviction of truth derived from scientific observation, or from other religious teachings.

Another kind of bigotry is that of the so-called scientist, who measures quantities of energy and matter and finds that certain results are always reproducible under certain conditions, — who finds that all the output of heat and mechanical energy of the human body can be exactly accounted for from the combustion of the food consumed, who finds that no matter or energy is ever lost from the universe, simply that they change form according to definite laws, and who concludes from all this that the whole universe can be explained on a physical and chemical basis, and denies the existence of spiritual forces and of religion.

Such a man is more narrow minded than the religious bigot. The religious bigot simply has never been trained to think logically. He finds something to believe and knows no better than to hold fast to that belief. The tenacity

(*Continued on page 100*)

PLANS FOR THE FUTURE

By DR. SAMUEL W. STRATTON
President, Massachusetts Institute of Technology

Since its inception, the Institute has always been noted for continual growth and progress. Its leaders have been men of exceptional creative imagination, foresight and courage, making possible the establishment of a scientific and engineering school which is unsurpassed by any similar institution.

However, Technology has not reached the limit of its development. It is still far from a full realization of the ideal of its founders. In keeping with the tradition of progress, therefore, every effort is being made to formulate and carry out plans which will bring us nearer to this ideal.

Whenever growth and development are contemplated in any organization the question of expenditure comes in. Adequate funds are necessary. In an institution such as Technology is at present, the funds required for expansion are necessarily large and must be obtained from without, which is usually a slow process, calling for an immense amount of effort. It is this factor of securing funds which frequently holds up progress. Therefore, it must be kept in mind that no definite time can be set as to just when the plans for the future, enumerated below, will be carried out to completion.

In considerations for the future development of the buildings, the question of adequate dormitories is among the most important. The Corporation, Faculty and Alumni are unanimous in the desire for more dormitories. Tentative plans are under consideration for the extension of the present dormitory system, utilizing the northeastern portion of the present grounds, just back of the Walker Memorial Building. This will not in any way interfere with the athletic field, but will help to finish off the grounds in that portion which is at present little more than dead space.

In connection with the educational buildings, there is an urgent need for a series of laboratories and workshops to provide for the heavier problems in connection with industrial research and engineering. Many of these problems, such as investigation of internal combustion engines, building materials, highway engineering, etc., require ground-floor solid foundations and convenient workshops. It is planned to meet this need by erecting a number of properly equipped buildings of a simple but semi-permanent design. These will be put up on the present grounds just in back of the main buildings. No further extension of the permanent educational buildings is contemplated at present.

The Institute needs a large building of simple construction which would adequately serve as a gymnasium and occasionally as an auditorium for large audiences. It would contain an indoor track and a swimming pool. The location would be on the present grounds, not interfering with the present athletic field, but near enough to make it available to the students at all times. Physical exercise during the winter months is a necessity, and its success will depend upon the accessibility of facilities. A swimming pool is one of the most useful and enjoyable means of providing winter exercise.

No remodeling of the Walker Memorial Building is contemplated at present. If a new gymnasium is built, it would relieve the present congestion and permit more space for student activities in accordance with the original design. A provision for the addition of an auditorium and gymnasium was included in the original plan of the Institute, but the necessary funds are not available at this time for a permanent building of the required size and style for the location.

It is hoped that the Great Court can be remodeled in such a way as to make it a practical and useful approach to the main entrance without marring its landscape effect in connection with the architecture of the buildings. The present lack of a suitable approach renders the main entrance useless and confuses visitors coming to the Institute.

As to the educational work of the Institute, plans are under way for the introduction of such additional courses as may be necessary to cover the newer developments in engineering such as highway, sanitary and automotive engineering. It is hoped that the courses in Physics and Chemistry can be extended to include the advanced research work necessary to secure fundamental data for the various branches of engineering, and that the biological work can be extended to include more work in the investigation of food transportation and preservation problems.

There is a demand in several of the departments for a longer course, especially for those wishing to prepare for research in science and advanced engineering. This will be met by offering more graduate courses but not at the expense of the regular undergraduate work.

Every effort will be made to strengthen the work in English. In this connection, the student should realize the value of being able to write and speak effectively. The business world is coming more and more to require this of an engineer, and it behooves the undergraduate to make use of every opportunity to perfect himself in this respect, much of which can

THE TECHNOLOGY SERIES

Unfortunately, Tech men can never avail themselves of every advantage their Alma Mater has to offer and many alumni, who for a period have been under her guidance, have never seen the new plant and have no way of knowing their Alma Mater's increased sphere of activity. This year, THE TECH ENGINEERING NEWS is making a special effort to ameliorate this situation in presenting this series of articles on the new Technology, its business management, the work carried on in the laboratories, and the plans for the future. This series, of which this article is the ninth, has been prepared by men thoroughly familiar with the phases they treat upon and is as follows:

THE TECHNOLOGY BUILDINGS ..... October
F. J. Whiting, Editor, Stone & Webster Journal.

THE GROUNDS AND THEIR DEVELOPMENT ..... November
H. J. Carlson, President Alumni Association.

THE BUSINESS ADMINISTRATION OF THE INSTITUTE ..... December
H. S. Ford, Bursar.

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RESEARCH AT THE INSTITUTE ..... May
Prof. H. M. Goodwin, Professor of Electrochemistry.

PLANS FOR THE FUTURE ..... June
Dr. S. W. Stratton, President, M.I.T.

be done outside the classroom by reading and participating in the various societies.

It is aimed to promote such coöperation and inter-relations of departments and courses as is necessary for the best interests of the faculty and student body. Endeavors are being made to determine just how each course can be improved.

The enrollment will only be limited by the number which can be adequately taken care of with the present equipment. The use of psychological examinations in helping to select men fitted for the Institute has been of too short a duration to determine whether they are successful or not. A further trial must be given them before they are either permanently adopted or rejected.

Only an outline of future plans can be given in this article. Each plan must be thoroughly studied and investigated before it reaches a final form. This entails bringing to light details far too numerous to be set down here. Enough has been given, however, to show that Technology intends to carry on its tradition of progress, going further each year towards a fuller realization of the aims and ideals of its leaders.

This article concludes the present Technology Series which has aimed to tell something about the buildings, laboratories and the business side of the Institute. Watch for the new Technology Series starting in the October issue. It will be the purpose of the new series to present articles relating to human and historical side of Technology thereby giving a contrast to the series which has just been completed and offering to our readers a more complete account of what the Institute is composed and what it stands for.

THE BEMIS DORMITORY PLAN

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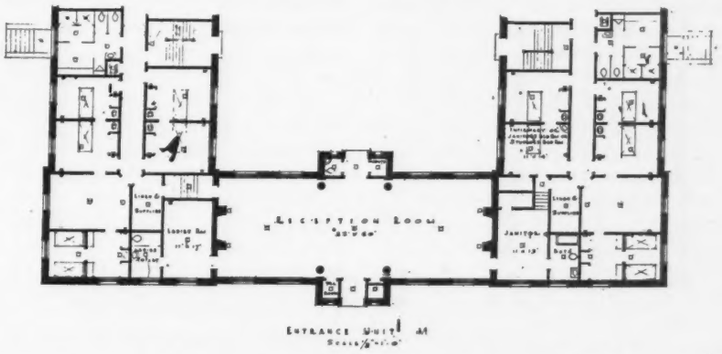
According to unofficial plans drawn by A. F. Bemis, '93, the new dormitories will be somewhat on the general plan of dorms recently erected at Harvard. They will embody some improvements over the present dorms and will be the very latest word in dormitory construction.

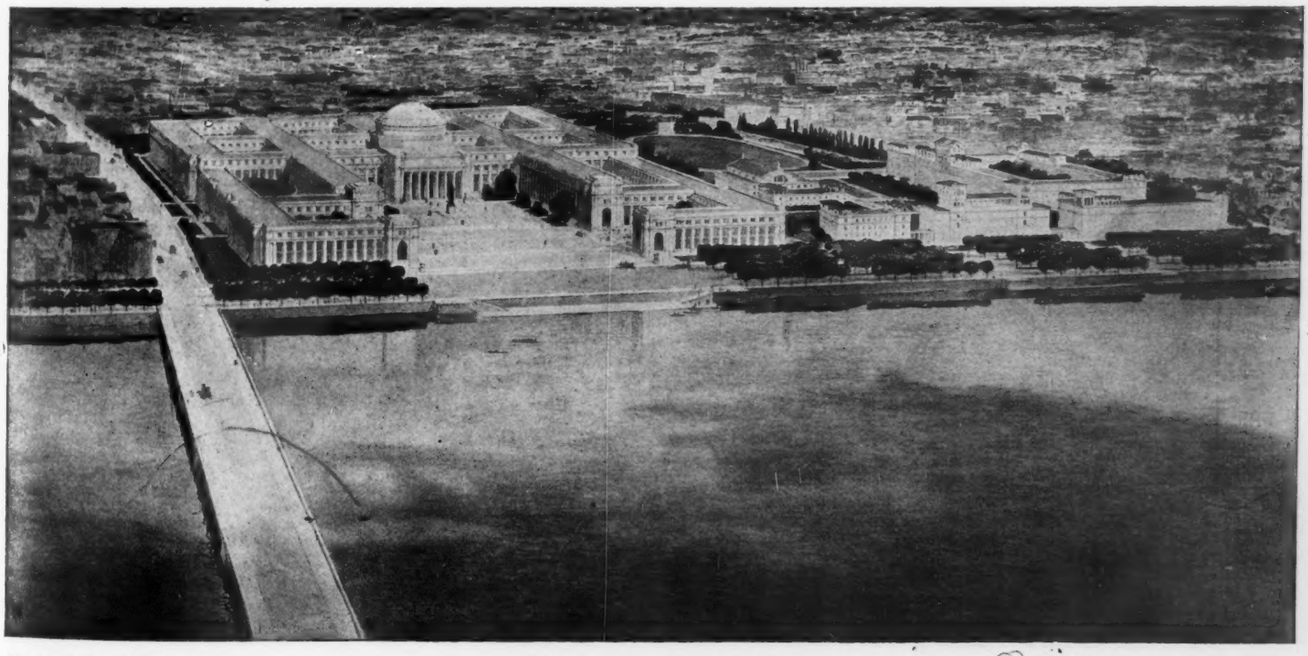


The main entrance will be between the side sections and will embody a large reception room, a ladies' room, office and telephone exchange with an infirmary for the students. Besides this, there will be several double suites on this floor. In the two side sections there will be both double and single suites. On the upper floors of these sections will be mostly single suites with several doubles at the juncture of the sections.

The double suites are much the same as the present ones with a study, bedroom, and dressing compartment. In addition they will have built-in closets which the present dorms lack. Each room will have running hot and cold water as at present. One of the big improvements is that every room in the new dorms will have an outside connecting phone which will be reached through a main switchboard in the superintendent's office.

There will be a preponderance of single rooms according to the new scheme. These will be larger than the present rooms and will be about the size of the studies in the present double-room suites.

Where these dorms will be placed and whether they will be of this plan is not known, as these are the plans of Mr. Bemis, who has been working on the dormitory question for the last ten years and had these plans drawn up last January as a basis for the operations of the committee in charge.



(Courtesy Technology Review)

THE NEW TECHNOLOGY

APPLICATIONS OF LIGHT WAVES TO MEASUREMENTS

By H. L. VAN KEUREN
Van Keuren Company, Allston, Massachusetts

American Industry teems with examples of the application of science. Electricity, for example, is used by nearly everyone, yet but few know or need know the intricacies of its generation and the reasons why it behaves in certain curious ways. Many, however, do know the numerous uses and how to manipulate electricity.

The application of light waves to the needs of modern industry for precise mechanical measurements is a most interesting example of how a bit of seemingly abstract physics has been employed to very good advantage. With light waves, it is as easy to measure in units of hundred-thousandths of an inch, as it is to measure with the machinist's micrometer caliper in units of thousandths of an inch. Light waves give an accuracy one hundred times greater than the micrometer with the same degree of care and skill. Furthermore, as the experienced machinist estimates tenths of a graduation on a micrometer, so the user of light waves estimates millionths of an inch.

But, one may ask, what is the need for such fine measurements as the hundred-thousandth and millionth of an inch? The answer strangely enough is speed, interchangeable manufacture, — quantity production. These are the first considerations and second come economy, reduction of the scrap pile, and our daily increasing need for greater precision, better tools and methods. Take, for example, the production of automobiles. Here is a product that is manufactured on a quantity basis. Interchangeability is a necessity. Parts are made by the thousands and even millions, in quite widely separated plants; and it is essential that when the various parts are assembled, they shall go together without fitting, without delay and with certainty of proper functioning. In order that this may be accomplished with parts often accurate within one thousandth of an inch, it is necessary for each plant to have standards accurate at least within one ten thousandth of an inch and preferably within one hundred-thousandth of an inch. Light waves make possible these standards by serving to check them as wear occurs, and provide an excellent means of transferring the accuracy of the primary plant standards to secondary standards or gages used in measuring the actual parts.

Again, in the production of watch hairsprings, light waves measure the width and thickness of the hairspring wire as it is rolled. With the best device available before the application of light waves about twenty per cent of the wire produced would be sufficiently uniform to give proper vibrations when coiled into a hairspring. Since the application of light waves the manufacturers are able to make eighty per cent of their production acceptable. Thus light waves, as a better method of measuring, have increased the production four hundred per cent.

The primary standards of industry today are flat precision combination gage blocks of rectangular, square, or preferably round cross-section. Two opposing surfaces of these blocks of hardened steel are lapped, as nearly as possible, perfectly flat, parallel and of the correct distance apart. These flat gages are arranged in sets of from five to eighty-one different gages. They may be combined by sliding or wringing them together, for when two gages are properly wrung together they are held by a very thin moisture, or liquid film, of but two or three millionths of an inch in thickness. Thus a few gages serve to make a standard for any size desired and the combination made is accurate well within one ten-thousandth of an inch. With a correct y arranged set of thirty-five gages, a combination may be made for any size in ten-thousandths of an inch from three-tenths inch to over fifteen inches, or in all over 150,000 different standards.

When an optical flat is placed on one of these gage blocks and viewed in mono-chromatic light, secured by passing white daylight or electric light through a red selenium glass screen, light and dark interference fringes or bands are seen. Figure 1 shows a gage block flat within one millionth of an inch, that is the dark bands are straight within one tenth of the distance between them. Thus simply with a perfectly flat piece of glass, — an optical flat, — one may inspect to within one millionth of an inch the degree of flatness of a surface sufficiently well finished to reflect light. If the bands are straight the surface viewed is flat, and if the bands are curved the surface is curved.

With light waves, a standard of length may be originated. The exact number of light waves in the length represented by the International Meter Bar at Paris is known to an accuracy

(*Continued on page 116*)

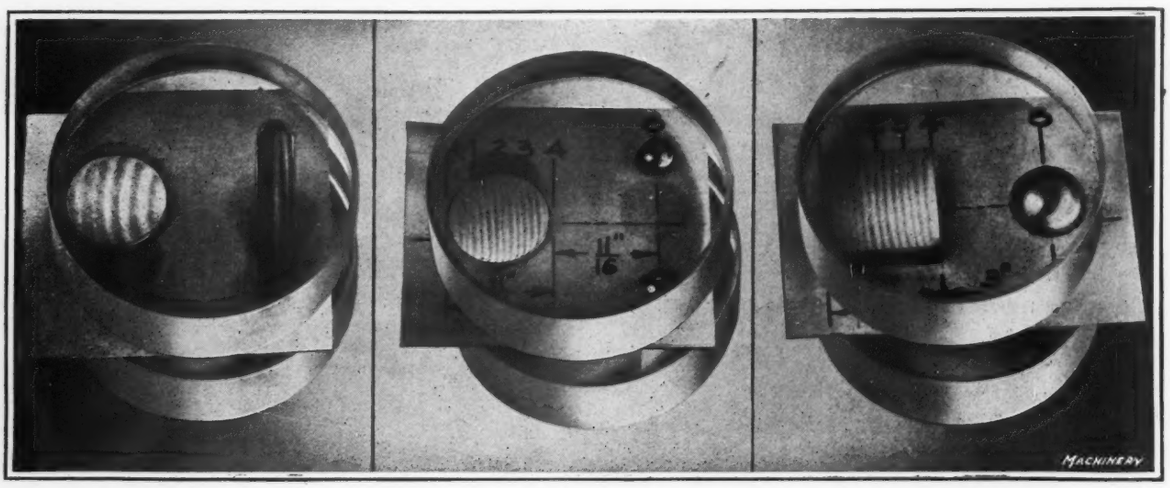


FIGURE 3

WATER-COOLED THERMIONIC TUBES FOR HIGH POWERS

By W. G. HOUSEKEEPER, '05
Engineer, Western Electric Company

The thermionic tube or vacuum tube, as it is quite frequently called, is an electrical valve in which a small quantity of electrical energy controls a much larger quantity of electrical energy. The current in the circuit to be controlled is made to pass between two electrodes of the thermionic tube, flowing from the anode or plate to the cathode or filament. A third electrode, the grid, is introduced between the anode and cathode and controls the flow of current between these two. The three electrodes are enclosed in an air-tight container which is thoroughly evacuated.

The conduction of current within such a highly evacuated space is accomplished by the emission of negative electrons from the heated filament, which pass through the grid to the plate. The electrons arrive at the plate with terrific velocities proportional to the voltage drop within the tube, and by their impact heat the plate. The number of electrons passing from the filament to the plate determines the current flow, so that the power to be dissipated from the plate is equal to the product of the current by the potential drop within the tube.

This loss in small tubes is usually dissipated from the hot plate by radiation. Using molybdenum as the plate material, the maximum safe dissipation is about fifty watts per square inch. In handling large quantities of power, sufficient plate surface must be available for dissipation of the unavoidable loss. Where the dissipation is larger than can be conveniently handled by one tube, a number of tubes are operated in parallel. However, with such operation in parallel it has not been found practicable to increase indefinitely the number of tubes so operated. Currents of exceedingly high frequency will circulate between tubes so operated, and safety devices must be provided to reduce or eliminate such circulation, and these devices become more complex the greater the number of tubes to be operated. Consequently, the problem of tube design for large power dissipation resolved itself into the determination of some means by which the energy dissipation per square inch from the plate could be materially increased.

Such an increase is obtained by making the plate part of the enclosing chamber of the tube. Thus one surface of the plate is exposed to air, while the other side of the plate is in high vacuum and in proper relative position with respect to the filament and grid. Consequently, the tube as a whole may be immersed in water, which, coming directly in contact with the plate, cools the plate by conduction. By such means, as high as 1,400 watts to the square inch have been successfully dissipated.

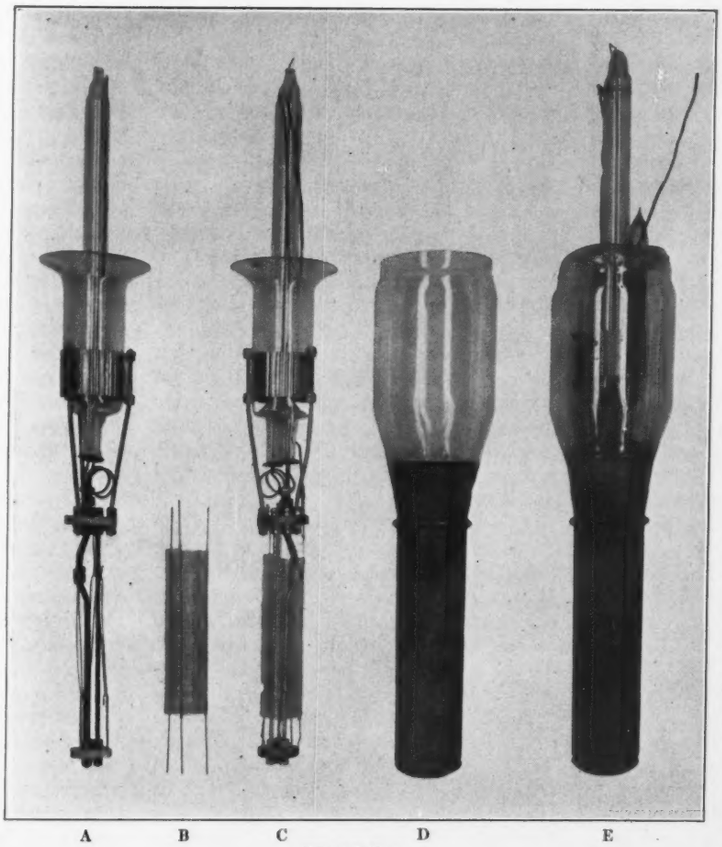


FIGURE 1

A tube structure embodying this feature is shown in Fig. 1. The complete tube is shown to the right at E. The lower portion consists of a copper cylinder approximately two inches in diameter, closed at the lower end. To the open upper flared end a glass bulb is directly sealed. This glass bulb, shown more clearly at D, serves to support the filament and grid structure, shown at C, within the copper anode. The tube operates at 10,000 volts direct current potential on the plate and will deliver 10 kw. of high frequency energy to a transmitting wireless antenna when used as an oscillating tube in a circuit with an efficiency of 67 per cent. Under these circumstances approximately 5 kw. is dissipated at the anode. The anode is clamped in a suitable casting provided with water inlet and outlet so that water may be forcibly circulated around the anode. By this means such a tube has easily dissipated 27 kw. The filament is of tungsten and the grid is made entirely from molybdenum. Perhaps the most interesting feature of this tube lies in the fact that for the first time copper has been sealed directly to and through glass. The anode is machined to a thin knife edge at the top. The glass is placed within the opening of the anode. The glass and copper are heated to as high a temperature as practicable, so that the glass wets the copper. As the joint thus made cools off, the copper, due to its greater coefficient of expansion, attempts to contract farther than the glass. The stress which the copper can produce in contracting is proportional to the thickness of the copper. In consequence the copper is made sufficiently thin at that part in which it is in contact with the glass, so that the stress which it can produce upon contracting is less than either the strength of the joint between the copper and the glass or of the glass alone; that is upon cooling the copper is prevented from contracting its full amount. Such seals will resist sudden changes in temperature such as are encountered in manufacture and use of the tube.

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WATER DISPERSIONS OF RUBBER COMPOUNDS

By WILLIAM BEACH PRATT
President, W. B. Pratt, Incorporated, Newtonville, Mass.

When Kaye made the announcement of his discovery in relation to the application of rubber latex to the art of papermaking, the attention of the technical rubber chemist was again focused on crude rubber, — rubber in the form as willed to us by nature.

For the past ten or twelve years, since the development of plantations for rubber was assured, a fairly staple price to the manufacturer has been established, and the chemist and chemical engineer have been devoting their time to the application of rubber to the art; new compounds, the acceleration of cures, and a development of factory practice, which has been most remarkable of accomplishment, and of tremendous economic value to the ultimate consumer of rubber goods, have been introduced.

Synthetic rubber has a history of its own. Nevertheless, with the natural product selling at a price far below that at which it could be gathered from the original forests of the Amazon district, it has offered little of interest to capital investment, and of necessity the rubber chemist had to forego his cherished dreams.

So, again, as we return to the study of nature's production of rubber and the suggested application of it in its most original form, the latex, the question naturally arose as to whether we might have lost something of value through present methods of coagulation.

Hopkinson, through his recent patent covering "Spray Coagulation" of the latex, to recover the entire serum content, has established a claim worthy of much attention. Through the research work of the commercial chemist during the past ten years, and his desire to accelerate cures, we find that nature's accelerators have been so far improved upon and new values established in relation to factory practice that the coagulated rubber of the plantations may be given a higher value in this regard, by the simple addition to commercially milled compounds accelerators that have been synthetically produced.

It seems only reasonable that the question of water dispersions of coagulated rubber, to supplement the use of natural latex, would be the first problem suggested for research work in view of the Kaye announcement.

When we think of what the research chemist, subsidized or employed by the manufacturer of rubber goods, has given to the world during this past fifteen years of almost unprecedented commercial production in any one art, is it not natural to assume that nature's work might be improved or even supplemented through the synthesis of a product resembling in character but differing in relation to specific results from that which nature had conceived when only meeting the needs of her own self-preservation or evolution?

It was this problem that was brought to the writer's attention through the announcement of Kaye. Many years ago, when rubber was selling at over a dollar per pound, we were working on the commercial production of a high-grade rubber from so-called "potential latex," such as is represented in commerce by "Pontianac" and those natural products still unused commercially but known through the local names "Cow Tree," "Oliver Tree," "Kill Tree," "Bread Fruit," and latex from like specie.

In the attempt to coagulate these products on the ground, in order to ship to this country for synthesis, it was found that under certain conditions an apparent water dispersion occurred of this potential rubber, at the time of coagulation. This was noted and filed, but no attempt to apply such information for the water dispersion of coagulated rubber was carried out. In fact, the value of such a process if successfully developed was not considered.

After many years such a value, — through a direct application of rubber latex to the arts, — seemed assured. It was now time to review the work of the past. A demand for what might be termed a new product, at least from a "commercial application" viewpoint, was to be promoted.

At this time the commercial value of such application of natural latex to the art was not considered. A call for such product had been stimulated, and only the question of possible local production from material at hand was of interest. Coagulated crude rubber, as received in the American market, was cheap in relation to its value in articles of manufacture. Could this be converted into a water dispersion that might supplement the use of nature's product, — which involved the shipment from the Far East of two pounds of water for every pound of rubber, — and at a price which would make it of economic value to the manufacturer?

As is rarely the case, the first attempts at the establishment of a laboratory demonstration of a theory proved successful.

We dissolved rubber in benzol, added a saponifiable agent to this benzol-rubber solution, such as oleic acid, and then slowly added, — while under the agitation of a mechanical stirring device, — water containing a saponification agent such as ammonia. The ammoniated water was equal in volume to that of the benzol, used in the original rubber solution. A change of phase occurred after about one-half of the ammonia water solution was added; the water, which at first constitutes the disperse phase, ultimately constituting the continuous phase and the rubber and its solvent the disperse phase of the emulsion. We found that the benzol could now be evaporated from the emulsion, leaving rubber dispersed in a water ammonia-oleic solution.

The next problem was to get rid of the soap solution, at least to a degree where it would have no effect on the curing of the rubber, in relation to either direct application or the mass after re-coagulation. This was accomplished by a mechanical method, which permitted of concentration of the rubber content without coagulation, so that a sixty per cent rubber dispersion in water was achieved with less than one-half of one per cent of soap present, a smaller amount than exists in the natural rubber latex.

It is of interest to here note that these dispersions could be preserved as the rubber latex, through the addition of ammonia, and that the dispersed rubber after dilution showed upon microscopic examination particles in size equal to that of the rubber latex and a similar Brownian movement. Further than this, the rubber was coagulated with the same reagents, in like quantity and under similar conditions as that practiced in the coagulation of the rubber from the natural latex.

While this work on the original problem was going on in the laboratory, we were also conducting experiments with the natural latex, both in its application to paper and fabric treatment.

Here was illustrated what is often the case in the carrying out of a well defined plan for research work, — the results did not warrant the time spent, or expenditure made. Experiments with the natural product did not come up to our expectations. The possibility that a substitute for same might have only a very limited application seemed apparent, and that no definite demand for either a diffused rubber or natural latex could be forecasted.

(*Continued on page 108*)

RECENT DEVELOPMENTS IN THE USE OF X-RAYS

By T. FUWA

Research Assistant, Research Laboratory of Applied Chemistry, Massachusetts Institute of Technology

The many ways in which X-rays have been put to use for the benefit of mankind well illustrate the potential value of discoveries in the field of pure science. In addition to the applications of X-rays to medical practice, they are used to some extent in the testing of materials — mechanical fabrics, airplane parts, and castings of a thin nature may be inspected rapidly and thoroughly by this method. Of still greater importance, however, from the standpoint of pure science, is the comparatively recent work on crystal structure, which has been made possible through the use of X-rays.

At the time of the discovery of X-rays by Röntgen in 1895 it was known that these rays were invisible, were capable of penetrating substances opaque to ordinary light, and of causing fluorescence in a number of crystalline substances. Shortly afterwards it was found that X-rays affected photographic emulsions and that they ionized gases. Several years elapsed before it was realized that X-rays of even low intensity would injure or sometimes kill certain kinds of living tissue. This property of the rays caused many of the pioneer investigators in this field to be severely burned, a type of injury which, unfortunately, is distressingly slow and uncertain of cure.

Prior to 1912 it was thought that X-rays could not be diffracted, refracted or reflected. In that year Laue, a professor at Munich, demonstrated the untruth of this belief by the use of a crystal as an interfering medium. He showed that the regular spacing of the atoms in a crystal actually form a grating capable of diffracting X-rays, whose wave length must, therefore, be of the order of magnitude of one ten-thousandth part of the sodium light wave.

Because of the remarkable properties possessed by X-rays, Röntgen quickly saw the possibility of using the rays in surgical diagnosis. As a matter of fact, the present field of X-rays in medicine is so extensive that few, if any, practitioners are thoroughly familiar with every phase of the subject.

The X-ray picture or radiograph is, in effect, a shadow record of the material interposed between the source of X-rays and the photographic plate or fluorescent screen. While these shadows are recorded in a single plane, the differentiation obtained is surprisingly good, especially in the region of the extremities of the human body. It is thus possible to study the structure of any of the bony parts of the body, including the skull and lower spine. At first, radiographs were used almost exclusively as an aid in the diagnosis of fracture cases but more recently bone diseases and other abnormalities, especially those resulting from tuberculosis have been studied by this means. So faithful is the recording of bone structure that even slight changes caused by a bone disease may be discerned. This is of considerable importance since the efficacy of a cure is generally dependent upon early treatment. Many radiographs may be made without any injury to the patient, and it is obvious that a continuous series of such pictures forms a most valuable history of the progress of disease with time.

Most foreign bodies encountered in surgery such as bullets, metallic splinters, and pins are of comparatively great density, and are in consequence practically opaque to X-rays. Hence their detection is a fairly easy matter. However, in order that surgical interference may be successful, it is usually necessary to know the exact location of the foreign body. As a result of the enormous number of cases requiring the extraction of bullets and shell fragments during the recent war, several ingenious methods of localization have been devised.

While a detailed description of these methods is inappropriate here, it may be said that practically all localization methods rest upon the same body of principles:

(1) The approximate location of the body is determined by a rapid search of the anatomical region in question.

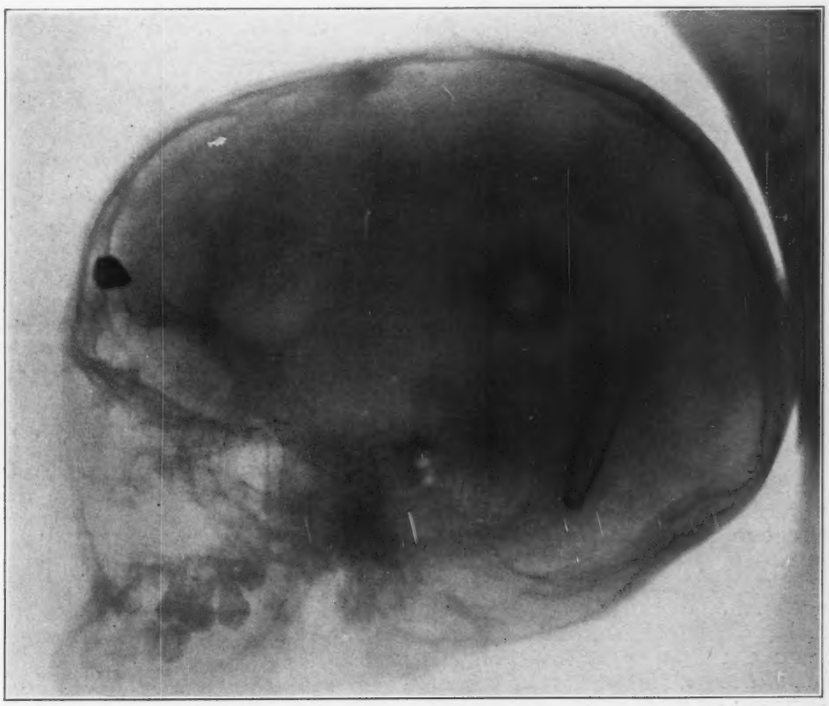
(2) The exact projection of the body in the horizontal plane is then indicated by the shadow cast by a vertical pencil of rays. This procedure is shown diagrammatically in Fig. 1.

(3) The X-ray tube is then displaced a known distance in its horizontal plane, causing a displacement of the foreign body shadow, the magnitude of which movement being in direct proportion to the depth of the body below the screen or plate used for observation.

By the aid of a table of displacement ratios, it is possible to localize the majority of foreign bodies with extreme rapidity and accuracy. The value of such information to the operating surgeon can hardly be overestimated, especially when under the stress of war conditions.

A number of prominent surgeons, mostly European, recommend the use

(*Continued on page 102*)



SHRAPNEL LODGED IN HUMAN SKULL

RECLAIMING 100,000 ACRES OF DESERT LAND

By FRANKLIN REMINGTON
Chairman of Board of the Foundation Company, New York City

The project with the strongest appeal to the red-blooded construction engineer is the one presenting the greatest number of obstacles. Some such undertakings draw the engineer into the crowded cities where heavy skyscrapers must be supported on unseen foundations extending to bed rock frequently over one hundred feet below the street level. Other difficult projects take him into uninhabited wilds where he wrestles in the open with great natural forces. Here, far removed from sources of supply, the engineer's foresight is put to a supreme test and the constant occurrence of unforeseeable obstacles brings his ingenuity into continuous demand.

The Gillespie Dam in Arizona, recently completed by the Foundation Company, is an outstanding example of obstacles successfully overcome in the open, far removed from convenient supply men and repair shops.

About sixty miles southwest of Phoenix, Arizona, is a tract of 100,000 acres which needed only water to transform it from an arid desert into one of the most productive farm areas in the world. The diversion of the Gila River promised to supply this one deficiency. The possibilities of the project were recognized even before the settlement of the city of Phoenix when original settlers built a dam and had the misfortune to lose it in one of the many floods. Thus the engineers of the present project had not only severe natural difficulties to surmount but also started with a previous failure staring them in the face.

Many years ago an engineer, James B. Girand, realizing that in time the Gila irrigation project was sure to go through, prepared plans for the dam and canals which he has had the satisfaction of seeing built under his supervision. His design provided for a diversion dam, eighteen hundred feet long and twenty feet above former water level, founded on rock. It is of the Eastwood Multiple Arch type. Its eighty arches and the entrance to the diversion canal are of reinforced concrete. The correctness of the design and the sturdiness of the construction have already been demonstrated by several floods. One point worthy of emphasis is that the upstream toe wall is keyed to bed rock, absolutely shutting off any seepage of water under the dam. The importance of this was realized when engineers discovered during a drought an underflow of one thousand second-feet or forty thousand miner's inches. This amount of water available when most needed was therefore saved for the project. The dam serves as its own spillway. Water flowing over the top falls into a basin in which is held four feet of water to act as a buffer. From this, water flows over a four-foot concrete wall out upon a one hundred-foot concrete apron which is protected from back currents by a concrete wall and sheet piles on the downstream side. Incidentally, the apron may be used as a roadway for auto traffic during a large portion of the year.

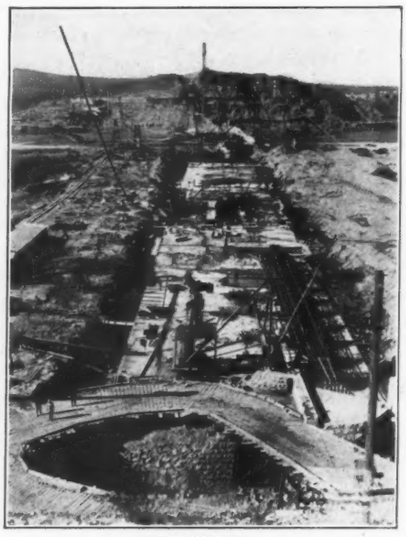


FIGURE 1
The Gillespie Dam under Construction

The first construction engineers to reach the site of the Gillespie Dam found themselves in a barren isolated country sixteen miles from the nearest railroad. The temperature ranged up to 120 F. About the only labor available was the green Mexican variety. A labor camp had to be built and a line of communication established to the nearest railroad. In the interest of economy, great care had to be used to select foremen and leading men who would have the stability to "stand by" the job from start to finish and who might be depended upon to produce only the most trustworthy work even under the most trying and unusual conditions. During construction, the contractor, without resorting to the extravagant measures frequently adopted as welfare activities, had to take pains to see that the employees were sufficiently happy to do good work, and above all, materials had to be routed with greatest care. A trifling omission in ordering materials might easily hold up the construction program and greatly increase costs by the forced holding in idleness of a large gang of laborers who on account of the isolated location could not be laid off as is customarily done near large cities.

The construction engineers translated forethought into intelligent action and at the end of sixteen months the dam was satisfactorily finished. Fifteen days before the estimated date of completion, the last buttress was placed. The bed of the stream looked almost dry. Nevertheless, within twenty-four hours water had backed upstream several miles. In two days, there were seven feet of water behind the structure and in a week the reservoir was sufficiently filled to allow the admission of a full head of water into the main irrigation canal whenever desired. Figure 1 is typical of the appearance of the dam during construction.

Over a year ago, the construction engineers who had spent sixteen months on the Gila River project packed up their dunnage and left for other operations, in other parts of the world. Meanwhile, the Gillespie Dam has been doing its duty. No defects, passed by listless engineer or foreman, have developed for the reason that each man during construction was keenly interested and took pride in his work. A considerable portion of the 100,000 acres watered by the forty miles of main canals and laterals has been planted and has yielded one or more crops. Today, cotton, dates, oranges, olives, grapes, pears, peaches and alfalfa are growing in the rich soil which less than two years ago was desert land. And thus without ostentation has been completed another permanent evidence of the public service constantly rendered by the construction engineer.

New Railway in Japan. The Imperial Railway Department has sanctioned the construction of the proposed railway between the cities of Nagoya and Uji-Yamada. The company in charge of this work proposes to construct a double track linestarting from Makinocho and terminating at Uji-Yamada, and also to establish several pleasure resorts at certain favorable places along the water front. The work will involve the construction of bridges across the Ibi and Kiso rivers at an estimated expenditure of Yen 700,000.

THE 1923 THESIS

The crowning event of a college man's life comes, so many say, not when he gets his degree but when he signs his thesis. At Technology, or in fact at any technical institution, the thesis means a great deal more than most people think. It may mean the advancement of an entirely new theory or the perfection of a new process or machine which will revolutionize some industry. More weight is given to a man's thesis by his future employer than is commonly supposed. Many theses are the direct result of suggestions made by a company which is interested in a man and which wants to see how he will work out a difficult problem. In this way it is possible for a company to get an idea of a man's ability and of course at the same time get a bit of research done for nothing.

Many theses are entirely too technical to be understood by readers who, even though they be engineers or scientists, are not in the particular field covered by the thesis. Many others are, however, of interest to anyone in that they deal with common ordinary things which we have often wondered about. One of these is "The Effect of Humidity on the Velocity of Sound in Air." Why is it that on a cloudy day we cannot hear so well as on a bright day? This is a question which we have often asked ourselves. J. E. Bastille is going to try to answer this question by June.

The Institute Corporation is going to grant nearly eight hundred degrees this June of which over five hundred will be the degree of Bachelor of Science. For each one of these degrees a thesis must be presented. It is with the most interesting of these that this article deals.

Nearly a fifth of the total number of theses are being made by Mechanical Engineering students. Course II is the "Old Faithful" in the family of courses and seems to lead in numbers, and they would like to think, of course, in quality at all times. This year their specialty seems to be new machines. T. G. Adams is endeavoring to design a machine which will automatically apply the "straight line brocading" to flat jewelry. D. P. Field is designing a machine to measure the horsepower transmitted to a generator by a belt. W. H. Hughes and F. S. Mann are trying to improve the Scott testing machine, and O. W. Lowry is designing a safety device for a punch press.

Just to show that a Mechanical Engineer is not confined wholly to mechanics, H. B. Gray is writing on "The Field of the Engineer as a City or Town Manager." This is an important field in which the engineer is to play a greater part in the future as it takes a technical training along with business ability to handle a position of this kind. More and more cities, especially in the West, are taking up this form of government, and many people predict that eventually all municipalities will be governed by managers instead of by politics as in the past.

Automotive engineering which, as far as reaching the end of knowledge is concerned, is still in its infancy, is receiving a great deal of attention. H. F. Culver and F. D. McGinnis are designing a machine to test fibre gears, in automobile timing trains, for noise under different conditions of operation, such as variable end thrusts and gear positions and sizes. J. J. Grabfield and F. A. Kinch, Jr., are investigating the effect of equalizer on the condition of brake lining and the brake action at various depressions of the brake pedal. E. E. Sanborn and H. L. Williams are making a study of the piston ring leakage in the internal combustion engine.

The compilation of data seems to be another popular subject as is shown by the three following. A compilation of tests on ammonia condensers with interpretation of the compiled data is being made by R. D. Ferguson. Mr. Ferguson hopes to establish the coefficients of conductivity and the law or laws which govern the flow of heat in ammonia condensers. W. R. Taylor is making a compilation of the known facts connected with the veneer industry together with experimentation of all points in dispute. He is being assisted by L. L. Tremaine. The finished thesis will give the entire history of the wood from the log to the panel. F. F. Lange is making a compilation of all available data pertaining to the properties of common metals at high temperatures.

Electrical engineering theses make up about a tenth of the total number to be presented in June, many of them being for the double degree granted to course VI–A men who receive the degree of Bachelor and also Master of Science upon the completion of their five years' training. Perhaps the most interesting work this year is being done in the new communications option of Course VI. J. K. Clapp and J. A. Stratton are working on the absolute calibration of a wavemeter. The object of this thesis is to provide a method whereby frequencies (or wavelengths) may be accurately measured over a range extending from audio—frequencies in the neighborhood of one thousand cycles per second—up to the extremely high frequencies used in radio. This upper limit is of about the order of forty million cycles or seven and a half meters.

Traction seems to be the outstanding feature of the field of electricity this year. W. C. Hahn and J. S. Keenan are investigating the adaptation of shunt motors to the Boston Elevated Rapid Transit system; W. E. Ames and R. J. Evans are making a survey of the Detroit Street Railway System, and P. R. Plant is studying the One Man Car.

Of course the water power question is a big one. W. R. Farley and I. L. Tyler are investigating the Ausible River in New York while A. J. Tigges and B. L. Chapin are making a study of the hydro-electric project at Smith River, New Hampshire; and H. H. Eder is designing an ideal hydro-electric power plant, and H. L. Townend is designing a smaller one.

There are several purely abstract theses such as "An Examination of Dielectrics" by J. M. Dawes and "An Investigation of Thermoelectricity" by R. H. Frazier. Others are: "Heating Effects in Small Motors" by W. L. Barclay and "The Electrical Distribution of Heat" by R. H. Park.

Telephony is represented by J. C. Sargent with his rating of telephone receivers based upon ampere turns and the installation and testing of an automatic telephone switchboard by E. W. Olcott, C. M. Mapes, and R. M. Goetchius.

One of the most important branches of electrical engineering is transmission. M. K. Chandler and J. H. Cox are investigating the dielectric losses in three phase cables and A. A. Gordon is studying the transmission of high voltages underground. Closely connected with transmission in the minds of most people is the lighting station. E. G. Pierce and P. Padgett are solving the problems connected with the Hartford Electric Light Company while H. Y. Hsu is remodelling and designing a lighting plant to be used in China.

The Civil Engineering theses this year are most of them specific projects for special places. Hydro-electric problems seem to be the most prevalent. G. E. Barnes and A. A. Kenny are testing one unit of the Amoskeag Manufacturing Company's hydro-electric plant at Manchester, New Hampshire and S. R. Evans and R. E. Rubins are investigating the water power at Barre Falls, Massachusetts.

N. Cohen and I. Robinson are conducting tests on concrete to determine the effect of "Cal" on different mixes

(*Continued on page 112*)

MONTHLY NEWS

Desulphurization of Coke by Steam. In the course of laboratory experiments in the desulphurization of coke by steam, steam tests at atmospheric pressure for the removal of sulphur from chunk-size coke have been finished, with encouraging results. Combined sulphur as FeS, $FeSO_4$ and free sulphur (not including solid solution sulphur) in Ohio coke was reduced from 1.38 to .72%. The solid solution sulphur was not affected, but it has been shown that this has very little effect in contaminating sponge iron in the blast furnace. In Illinois coke .62% sulphur corresponding was reduced to .48%. Clairton coke low in sulphur was reduced from .29% to .17%. Sulphur in a sample of gashouse coke from Philadelphia was reduced from .81% to .60%. These results were obtained without application of vacuum which may reduce still further the amount of sulphur. Very little steam is required — three grams of steam per gram of coke per hour were employed, which is a big excess. Iron will be heated in contact with the treated coke and the transfer of sulphur determined.

Public Works in Colombia. It is reported that the Ministry of Public Works at Bogota contemplates the construction of an aqueduct at Buenaventura to insure a continual supply of water to the town, which depends at present on rain; that the Ferrocarril Pacifico (Pacific Railroad), under the direction of the same Ministry, is planning to construct a modern hotel at Buenaventura, and that the Department of El Valle del Cauca is about to purchase a dredger to deepen the channel of the Bay of Buenaventura and also to dredge alongside the pier here.

Twelve Million Dollar Extension of Port of Naples. The Italian Government has guaranteed the sum of Lire 240,000,000 (about $12,000,000), for the extension of the port of Naples. The government has approved a considerable series of works which, it is announced, will be begun immediately. Part of the construction work, according to "Il Mezzogiorno," has already begun. The financing of this project is to be in ten yearly installments of 24,000,000 lire each. This is about $1,200,000, and it is calculated that the project will be completed by 1933.

Revenue from Public Lands. The amount of revenue accruing to the Federal Government and States from oil and gas produced on public lands continues to increase rapidly. The royalty value of oil, gas and gasoline produced from operations on Government lands in January, the latest month for which complete figures are available, is $1,074,512. In comparison with the figures for July, 1922, which were $648,056, an increase of 65 per cent is shown. During March two new oil wells were brought in on Government lands in Montana. Actual drilling operations were commenced in March in the Cold Bay oil field on Government lands in Alaska. On April 1, a total of 10,608 permits for prospecting for oil and gas on Government lands had been received from the General Land Office. A total of 334 leases for oil and gas production operations had been issued on the same date.

Total net royalties for the production of oil, gas, and gasoline on Government lands, submitted up to April 1, amounted to $11,684,904. This figure represents operations in the States of Wyoming, California, Montana and Colorado. During March, 37,980 barrels of oil were produced on Naval Petroleum Reserve No. 3 (Teapot Dome), Wyoming, on which the royalty barrels amounted to 6,252.74 and the royalty value to $13,175.71. Production for March on Government lands in the Winnett, Montana district amounted to about 166,000 barrels of oil.

Colorado River Treaty. As soon as the legislature of Colorado ratifies the treaty on the water power project of the Colorado River this important work can be started.

This project has been held up due to the conflicting bills concerning water power rights before the legislature of Colorado and also because the members of the legislature desire to know more about it before putting the matter to a vote.

The main features of the treaty are the apportionment of 7,500,000 acre-feet of water annually to each of the upper and lower basins for beneficial consumption, and in addition the apportionment of 1,000,000 acre-feet annually to the lower basin. Domestic and agricultural use was decided to be of primary importance while power was secondary and navigation subservient to other uses.

The development of the Colorado River for the protection of irrigationists in the lower basin is an urgent necessity. The time is approaching when the water powers of the Colorado will be needed to augment the existing supplies of electrical energy to keep pace with the industrial and agricultural growth. No agreement involving affairs of such magnitude as does the Colorado River Treaty can hope to satisfy every one. No one claims that the treaty is perfect, but it is the best expedient that has been offered after several years of turmoil. In the interests of all parties involved it should be ratified. — *Journal of Electricity and Western Industry.*

Measurement of Pressures of Coal Dust Explosions. The electrostatic method of measuring pressure, developed in the J. J. Thomson laboratory, will be used by the Department of the Interior at Pittsburgh, Pa., to measure pressures generated by coal dust explosions. The method completely eliminates moving parts and effects of inertia. A metallic plate is covered on both sides with sections of tourmaline crystal properly oriented; two other plates are placed on the opposite sides of the crystals. These plates receive the static charge when pressure of explosion is exerted upon the crystals, and transmit it to plates in a vacuum tube which influence an electron stream. The electrons are emitted from a hot filament, a portion passing through a pinhole. The stream is then acted upon by a special electrostatic and an electromagnetic field and finally impinges upon an oscillating photographic plate where the deflection generated by the pressure is recorded.

Electric Railway Extensions in Spain. Specifications have been issued and bids will be received until June 20, 1923, for equipment for the electric railway which is to be constructed to connect Vigo, Spain, with the towns and villages of Redondela, Canido, Penjon, Ramallosa, Bayona and Gondomar. Seventeen kilometers of new lines will be laid on existing wagon roads, and another seventeen kilometers will run across country on roadbed that must be constructed.

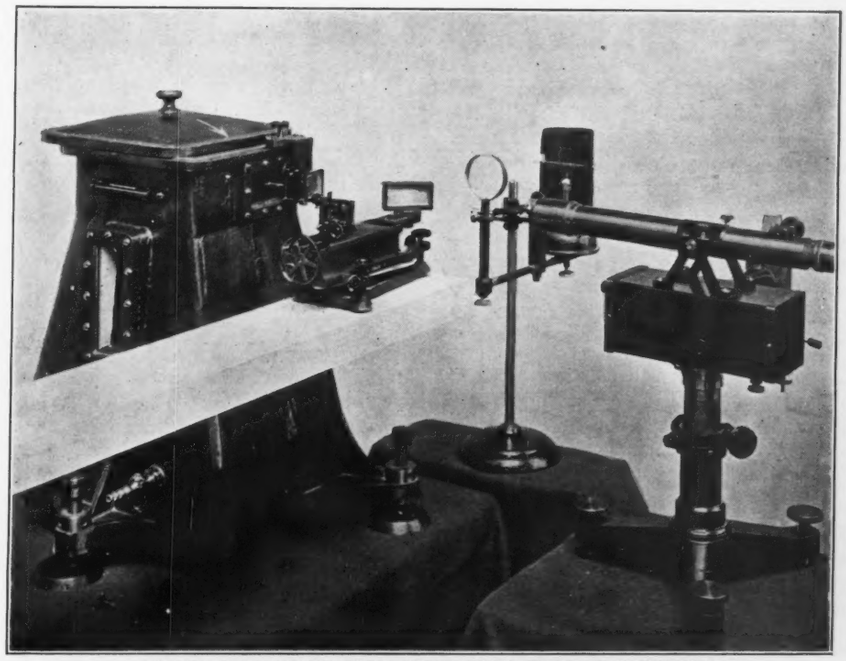
Valuable Pendulum Apparatus Acquired by M. I. T. The department of Physics of M. I. T. has recently purchased from the firm of C. L. Berger & Sons, of Boston, a half-seconds pendulum apparatus for measuring the force of gravity. This particular instrument was the last one of a set of three made by this firm and probably the only one available in this country. The other two pendulums were sold to the governments of Argentina and Mexico.

The pendulum is of the "invariable" type, is made of aluminum bronze, and rests upon an agate knife-edge which is mounted on the support. An agate plane set into the head of the pendulum is in contact with the knife-edge.

The pendulum is swung in an air-tight case from which nearly all of the air has been exhausted. A single "swing" usually occupies twelve hours. By means of an electrical device the oscillations of the pendulum can be compared with the half-second beats of a chronometer, the rate of which has been determined either by astronomical observations or by the Washington time-signal received by radio. The motion of the containing case set up by the vibration of the pendulum itself is detected and measured by means of an interferometer, and the effect of this motion on the period of the pendulum is computed and allowances made.

The precision attainable with this apparatus seems incredible until one is familiar with the method. Owing to the length of the swing (eight to twelve hours) and to the manner in which the period is calculated an error of one or two seconds in the direct observation of coincidences produces an error out in the seventh decimal place of the 0.5s period, or less than a millionth of a second.

The possession of this rather rare instrument by the Institute will make it possible for advanced students in geodesy or physics to undertake measurements of gravity of the highest degree of accuracy.



SET-UP OF INTERFEROMETER USED WITH PENDULUM

Telescope is farther away from receiver in actual practice.

BOOK REVIEWS

The Young Man and Civil Engineering. By George Fillmore Swain. The Macmillan Company. New York. Cloth, 5½ x 8 inches, 199 pp. + xi and index, 1922.

The most important question which a young man has to decide is the question of his vocation. Especially true is this of a man who wishes to take up engineering. The several branches of engineering are so specialized that a man must be interested in his work in order to succeed in it. This book not only treats Civil Engineering as a profession but it treats all engineering as well in a general way that is very helpful to one who is not quite certain what he wishes to do.

In the introduction the author gives a general history of engineering and defines it as follows: "Engineering is the science and art of applying, economically, the materials of nature for the use, convenience or enjoyment of man." This is very complete and is also understandable and conveys the ideal of helpfulness which everyone in the profession should possess.

It is evident that the author is very proud to be an engineer and that he believes that it is the only profession for a young man who believes in it as he does. It is also evident that he is the authority that he most certainly is in the clear, concise and yet interesting way that he develops the various branches of Civil Engineering in the second chapter. He outlines Civil Engineering as follows:

1. Surveying and Geodesy.
2. Railroad Engineering.
3. Highway Engineering.
4. Hydraulic Engineering.
5. Sanitary Engineering.
6. Structural Engineering.
7. Municipal Engineering.

and then proceeds to take up each item in detail with many illustrations and shows that each has certain qualifications and differences from every other one.

To one who is not certain what branch of engineering he will take up this is easily the most important part of the book. But he should also read further and decide whether he has the qualifications necessary as they are outlined in the third chapter. They are:

1. A knowledge of the forces of nature and of the laws governing them; in other words, a knowledge of natural science, logic, and mathematics;
2. A knowledge of the materials applicable in construction;
3. A training in those branches of knowledge which have to do with the economical adaptation of means to ends;
4. A perception of the true relation of things, or a sense of proportion which will indicate what measures or projects that are physically possible will really conduce to the use and convenience of man. These are professional qualifications. Further, a man must have certain personal qualities such as: judgment, balance, a trained mind, experience, initiative, good health and knowledge.

Characteristics of Civil Engineering as a profession and the outlook for the Civil Engineer are analyses of present conditions which will prove helpful in a general way. The final chapter, Concluding Suggestions, is very important. In it is some excellent advice. This advice may apply equally well to men in the first year at training school and to men of old standing as engineers.

Taken all in all the book may well be recommended, to men who are already in the profession, to men who are contemplating entering it and to anyone else it will prove interesting reading.

EDITORIALS

INAUGURATION

An inauguration is not an everyday occurrence in the life of an institution. If it were it would be treated accordingly and little or no ceremony would be connected with it. But due to its being the exceptional occasion rather than the commonplace, it deserves a fitting ceremony.

The Institute is notoriously rugged and severe in all its functions. Heretofore its exercises have been accompanied with that austere simplicity which seems to have characterized the New England ancestry. The President of the United States is given the oath of office amid much pomp and formality. In his own sphere, the President of Technology holds a similar position. Therefore as a tribute to the man who is to be at the head of the Institute and as a means of investing the ceremony with that impressiveness and solemnity which it demands, President Stratton's advent to office should be marked by the extraordinary, rather than the usual.

The exercises of the Institute have been characterized as "gauche." This is undoubtedly true in some respects, but it is rather the absence of exercises that arouses the comment. Anyone not intimately connected with the Institute is astounded at the lack of ceremony, and to many who know it well, this lack is ill-explained. The outsider is at first incredulous that such a state exists, and then astonished. To those who have seen its "exercises" the disappointment is deep.

The responsibility of remedying this regrettable condition devolves upon every one of us, faculty and students alike. Much can be added to the Commencement exercises by the wearing of caps and gowns and it is ardently hoped that the faculty, undergraduates and everyone connected with the exercises will endeavor in every way to create the atmosphere which has been lacking for so long.

TO THE SENIOR

Commencement, the last formality of college life, is fast approaching, and the Senior, with his new ideas and ambitions, stands upon the threshold of the world. He will start out during a period of increasing business prosperity — a time when his opportunities will be greatest.. Statistics show that the positions offered far outnumber the graduates, making a wise choice possible.

It is well to keep in mind at this time certain facts which cannot be denied. The Institute degree will obtain a position for the departing Senior but its usefulness ends there. It will not work for him. Whether he holds his place and progresses depends entirely on the quality and quantity of his work after obtaining a position. Effort is the foundation of success in any line.

The Senior Class is to be congratulated as a whole for introducing and supporting so well such a commendable form of endowment fund. It is hoped that after graduation our Alma Mater will not be forgotten and that each man will see to it that his share of the fund is paid regularly up to its maturity. If this is done the Class of 1923 will have established a precedent which every succeeding class may well follow.

The Tech Engineering News takes this opportunity to bid the departing Seniors farewell, and to wish them most earnestly the best of success in future undertakings.

COMMERCIAL AIR TRANSPORTATION

The United States has always been confronted with the problem of transportation. Its rapid territorial growth in the early days made a solution absolutely necessary. The industry and enterprise shown in meeting the situation on land and sea have won for this country the business leadership of the world and made it the richest nation ever known.

The transport problem, however, is not completely solved. We have gone about as far as it is possible in land and water transportation and still something remains to be accomplished. It is natural, therefore, that we should turn to a more recent development for help, and that development should be aviation.

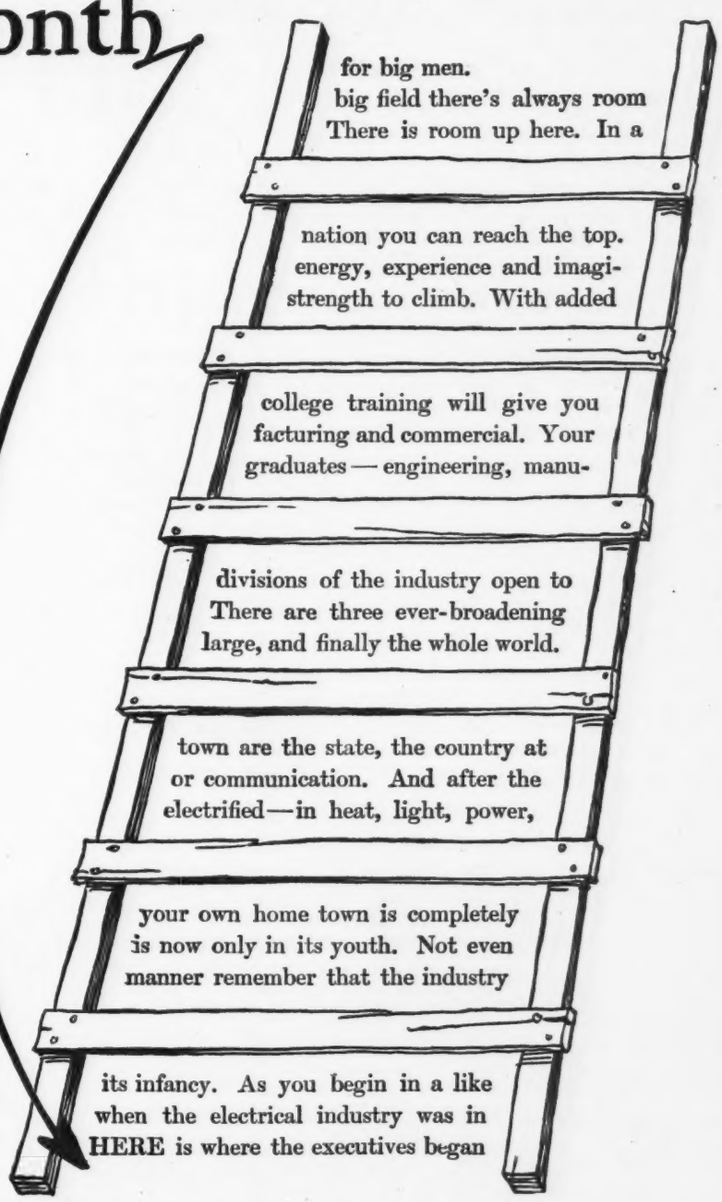
There is no doubt that the aeroplane has come to stay. Far-sighted individuals have recognized its practical application for many years and it is encouraging to note that air transport, within very recent times, has taken on a serious aspect which now challenges American business.

Time is a very large factor in business, especially in America which is a speed-loving nation. In our transportation development, the insistent note has been speed, more speed, because every added hour or even minute in transit adds to the cost of doing business. Here then is the great field for commercial air transportation.

But each transport system has its limitations, first as to the highway it uses and second as to the equipment it has to provide. Water and air are still the only open highways. However, they too must be subject to regulations for the good of all. One of the most urgent needs of commercial aeronautics at the present time is basic national legislation providing for appropriate regulatory procedure. Such legislation should be broadly conceived to include the adoption, administration and improvement from time to time of an Aeronautical Code under proper government authorization. The Department of Commerce should be provided with adequate facilities for promoting the regulation and development of commercial air transport operations in interstate and foreign commerce. Intra-state legislation and operations should conform as nearly as possible to the basic Federal legislation, or at least there should be unified State action. This is only a bare outline of the legislation necessary for adequate regulation and even this can be accomplished only through widespread public support.

The second limitation, that of equipment, can only be met by the formation of a great ground organization. This will necessitate the coöperation of districts and localities in providing properly equipped air harbors and intermediary air lanes under unified Federal control. Coöperation of the Government along certain lines of national aerologic and radio broadcasting service must be had. An adequate motor collection and delivery system between air ports and business centers is essential. In this connection, it is highly desirable that the valuable pioneer development work of the Air Mail be continued until substantial realization of the above essentials permits of private enterprise.

To men who begin at the bottom – next month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There is room up here. In a
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divisions of the industry open to
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large, and finally the whole world.
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WATERPROOFING CONCRETE

By J. S. MAYNARD
The Richardson Company, Chicago

The desirability of having an impermeable concrete in such places as restaurants, dairies, stables and other places where a considerable amount of water is used has long been felt. Originally, the question of waterproofing involved mainly the physical troubles from water passing through concrete without any special consideration of its effect on its durability other than a gradual leaching out of the cement. Recent experiments suggest the possibility, that owing to the increased conductivity of damp concrete to electrical currents, such currents, if present, may so affect damp concrete as to seriously lessen its integrity.

Many attempts have been made to render concrete waterproof. Though the methods may differ considerably in detail they all fall under two general classes: (1) the integral or cement method and (2) the surface method. The first consists of mixing some compound with the concrete in order to render the cement itself impermeable to water. This compound may be either added to the cement dry or it may be mixed in with the entire batch later on. The surface method consists in applying to the structure after it is built some compound which will adhere to the concrete and form a water-tight skin over it.

The interest in this subject has been so great that the American Society for Testing Materials appointed a Committee on Waterproofing Materials to study the matter. After nine years of work they have brought in their report which has subsequently been adopted by the Society. Considering first the integral or cement method, the committee finds that it cannot waterproof against cracks. Neither can it protect and insulate against electrolysis. The majority of patented and proprietary integral compounds tested have little or no immediate or permanent effect on the permeability of concrete and some of these even have an injurious effect on the strength of mortar and concrete in which they are incorporated. Some of these substances are dependent for their effect upon the action of organic compounds. In such cases their permanency is very doubtful. In view of their possible effect, not only upon the early strength, but also upon the durability of the concrete after considerable periods, the committee recommends that no integral waterproofing should be used unless it has been subject to long-time practical tests under proper observation to demonstrate its value, and unless its ingredients and the proportion in which they are present are known.

While external treatment of concrete would not be necessary if the concrete itself, either naturally or by the addition of waterproofing material, was impermeable to water, it has been found in practice that in large construction, no matter how carefully the concrete itself has been made, cracks are apt to develop. These are due to shrinkage in drying out, expansion and contraction under change of temperature and moisture content, and through settlement.

It is, therefore, often advisable on important construction to anticipate and provide for the possible occurrence of such cracks by external treatment with protective coatings. Such coating must be sufficiently elastic and cohesive to prevent the cracks extending through the coating itself. The application of merely penetrative void filling liquid washes will not prevent the passage of water due to cracking of the concrete. The Committee has, therefore, divided surface treatment into two heads:

(*a*) Penetrative void-filling liquid washes.

(*b*) Protective coatings, including all surface applications intended to prevent water coming in contact with the concrete.

While some penetrative washes may be efficient in rendering concrete waterproof for limited periods, their efficiencies may decrease with time and it may be necessary to repeat the treatment. Some of these washes may be objectionable, due to discoloring the surface to which they are applied.

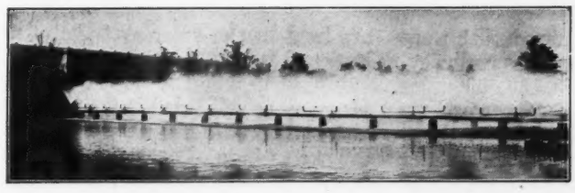
The use of bituminous or asphaltic coatings naturally suggests itself. It was found that their durability and efficiency are very largely dependent on the care with which they are applied. Such care refers particularly to proper cleaning and preparation of the concrete to insure as dry a surface as possible before application of the protective covering, the lapping of all joints of the membranous layers, and on their thorough coating of the concrete with the protective material. The use of this method of protection is further desirable because proper bituminous coverings offer resistance to stray electrical currents, the possible attack from which was referred to in the beginning of this article.

There are in all waterproofing bitumens certain essential constituents and it is in the proper balancing of these constituents that the secret of the value of good waterproofing lies. A few years ago asphaltic bitumens were only known to contain asphaltenes and malthenes. Today, research has developed the fact that there are to be found asphaltic waterproofing bitumens, free from asphaltus acids, asphaltic anhydrides, asphaltic resins and carbenes, as well as asphaltenes and malthenes. Certain of these constituents are vaulable and certain others harmful. For example, it is now known that many so-called natural asphalts contain high percentages of asphaltic acid and anhydrides as well as carbenes. Carbenes are an indication of overheating or burning. Asphalt derived from certain points in the Mexican fields on the other hand contains less acids and anhydrides than any other asphalts. A valuable constituent in a certain proportion is the asphaltic resin (not rosin). The resins when properly combined with the malthenes give the required adhesiveness and ductility to asphalt, while asphaltenes lend stability and cohesiveness.

It was the discovery that the proper blending and treatment of these different constituents would result in a perfect waterproofing compound that led to the development of "Viskalt." It would be described by a chemist as a polymerized series of hydro-carbons; polymerized under vacuum and containing over 99.9 per cent pure bitumen. The proper blending of one series of bituminous hydro-carbons lends a maximum adhesiveness while the addition of others gives maximum cohesion. The formula under which the physical characteristics of "Viskalt" is controlled is identical with that of the recent recommendations of the American Society for Testing Materials for waterproofing compounds.

Viskalt compounds are applied in waterproofing between layers of felt, Viskalt saturated and coated, using two or more layers so as to form a continuous membrane on the outer surface. This is protected from damage by one or two courses of brick or a one-inch surfacing of Portland cement. Foundations are waterproofed in a similar manner excepting that the membrane is applied over the concrete and then protected.

Watch for the new Tech Engineering News in October.



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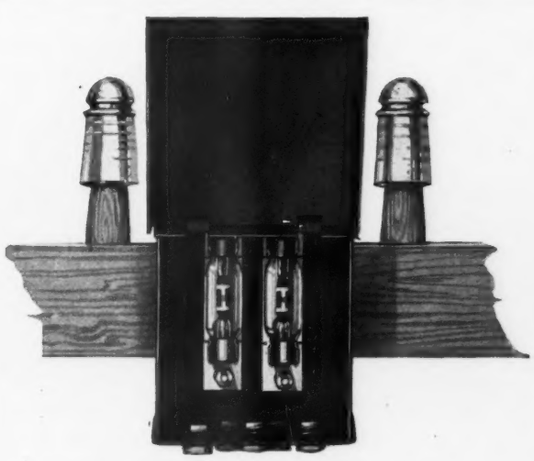

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Haughton tandem gearing eliminates end thrust. No end thrust bearings are required.

Tandem gearing is durable, efficient, safe and reliable.

Eight of the largest automobile and tire companies use 396 Haughton Elevators in their plants, and 379 of these elevators are tandem geared.

The economy of this type of elevator construction under heavy duty conditions is one reason why forty per cent of the orders for Haughton Elevators are re-orders.

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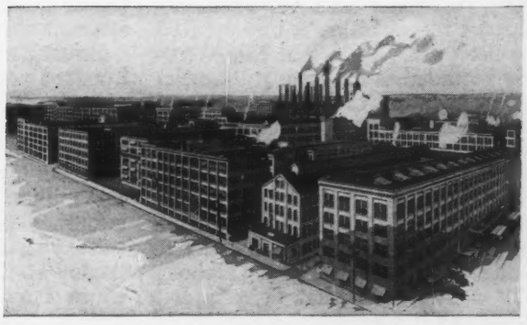

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THE UNITY OF SCIENCE AND RELIGION

(*Continued from page 85*)

of his belief is commendable. But the scientist is supposed to be a trained thinker. For him to deny everything not revealed by the five senses is unpardonable. Why should he think that truth should be revealed alone by the five senses that he happens to possess. If God had not given him the sense of sight, his feeble intelligence would probably never have guessed of the possibility of such a sense of perception. Why then should he imagine that there may not be possible senses which may perceive truths of which he has never dreamed. Why should he ignore his emotions which ought to tell him that he is a part of a great plan of creation which it is the function of religion to interpret.

Charles P. Steinmetz recently stated his conviction that religion and science are not antagonistic; that they are two great but different forms of activity of the human mind.

Religion and science have the common object of trying to understand ourselves and the world in which we live and the relation of one to the other. If we try to define the fields of each, we would say that religion lies in the spiritual field and science in the material field. But are these two distinct fields? They appear so, of course, but are they so in reality? We must admit that they interpenetrate to a considerable extent and that a sharp line of demarcation cannot be drawn.

The progress of science in the past twenty years has been very remarkable, and forces hitherto unsuspected have been discovered, and things formerly regarded as the most substantial have been found to be no more real than a configuration of motions.

Take for example solid substances. The direct evidence of our senses tells us that iron and glass are rigid and impenetrable. Yet light passes through glass; X-rays pass through substances opaque to ordinary light. Nobody really understands what light is, but it is usually supposed to be propagated as a series of waves through an all-pervading medium called the ether, much as sound is propagated as waves through the air, or as ripples are propagated across the surface of a pond. Light is not regarded as a material substance, but let us consider the possibility of solids, glass or iron, or any other solid being penetrated by material substances. If we throw a lead bullet against a pane of glass we know that the pane is shattered. If, however, we fire the bullet from a high-powered rifle it drills a clean hole through the glass. Now let us speculate what would happen if the bullet were endowed with an enormous velocity. The velocity of light is 190,000 miles per second. Suppose, however, we content ourselves with one tenth of this velocity, or 19,000 miles per second and let us imagine we could construct an engine capable of projecting a lead bullet weighing one sixth of an ounce with this velocity. To do this our engine would have to perform an amount of work equal to that necessary to bring five thousand railroad trains weighing one thousand tons each up to an express speed of sixty miles per hour. If the bullet travelling at this velocity should strike the pane of glass, the probability is that it would not even make a hole as it passed through. It is hardly likely that we will ever be able to put this experiment to the actual test with lead bullets, but nature provides us with very small missiles which travel with the enormous velocities approaching that of light.

Radium and similar materials are known to emit rays which consist of material particles called alpha particles, and are shot forth with about one tenth the velocity of light. These particles shoot through glass and sheets of gold, lead and all solid substances without puncturing them.

This argument is cited as the most likely to convince the layman of the unsubstantial nature of solid matter. The scientist, however, possesses today much corroborative evidence which it would be difficult to present in the space at our disposal.

Scientists have believed for over a hundred years that matter consists of atoms. To show the smallness of atoms it may be stated that a lead bullet weighing one sixth of an ounce contains fifteen thousand million million million lead atoms. Until recently scientists postulated that the atoms were solid, impenetrable and indivisible. Today atoms are believed to be miniature solar systems consisting of a nucleus corresponding to the sun, with electrons, corresponding to the planets of our solar system, revolving around the nucleus. A comet shooting at our solar system will usually pass through the empty spaces and not hit sun or planets. Likewise the majority of the alpha particles, the projectiles shot out by radium, will pass through atoms without striking nucleus or electrons. The atoms then consist mostly of empty space; the electrons are at enormous relative distances from the nucleus and are held in certain definite orbits or configurations by electrical force, just as the planets are held in the solar system by gravitational force.

Formerly when it was thought that atoms were solid and indivisible it was also thought that there were as many different kinds of atoms as there were kinds of elementary material substances, that is about eighty. Today it has been proven that the elements are transmutable, that lead atoms and gold atoms are built of exactly the same materials although man will probably never succeed in transforming lead into gold on a commercial scale.

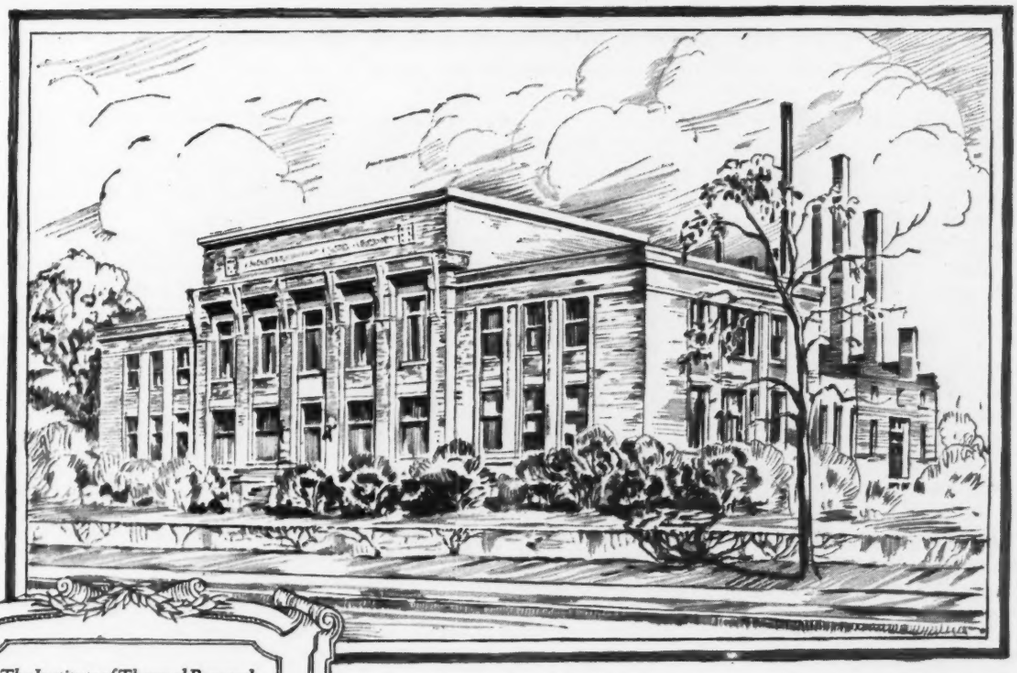
It is now generally recognized that the atoms of matter are very complex, but that all atoms are built of exactly the same ultimate units, which are in fact the atoms of electricity, of which there appear to be two kinds, atoms of positive electricity which are called protons, and atoms of negative electricity which are called electrons. What are protons and electrons? Science has not gone so far as to make even a serious guess as to this.

Science has taken away from us the reality of our solid material objects and shown that it consists only of a dispersed system of protons and electrons in certain configurations. We might at least hope that the electrons and protons might be conceded a material existence but the indications are that such even is not the case. They appear to be nothing more than energy manifestations in the universal medium which fills space.

A smoker puffs smoke in a certain way and makes a smoke ring. The smoke merely makes the ring visible, for if he puffs in the same way with no smoke in his mouth he would make a similar ring but it would not be seen. This visible smoke ring, or the invisible air ring, has no material existence other than its being a manifestation in the material air, yet the smoke ring is a real thing. If it were not for the friction of the air which slows down the whirling motion, this ring, once started, would continue forever. Electrons and protons are undoubtably manifestations in the ether, as smoke rings are manifestations in the air. The human intelligence is not yet capable of understanding the ether and so our conception of protons and electrons can be no more definite than that they are manifestations in the ether.

One must marvel at the accomplishment of the scientist in unravelling so many of the mysteries of the material world, especially when his means of observation are limited to his five very inadequate senses. It is a very narrow

(*Continued on page 102*)



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THE UNITY OF SCIENCE AND RELIGION

(*Continued from page 100*)

minded scientist who thinks that there is nothing in nature that has not been revealed to him. There are probably spiritual forces in the universe of more power and importance than any of the material forces revealed as yet to the scientist. There may be dormant senses, which man is capable of developing, which will reveal these spiritual forces. Our consciousness itself is a spiritual force about which we understand very little. It is the function of religion to contemplate our consciousness and our various emotions, awe, reverence, love, and through them to help us understand ourselves and our purpose in the world. The scientist invents his hypothesis and theories to help him understand the natural world, and some other scientist may scorn the theories. Religion has its creeds and dogmas, which are the hypotheses put forward to explain man's spiritual existence. We are prone to scoff at the creeds and dogmas of other tribes than our own, but to do so is bigotry. Surely, none of the creeds, not even our own, express all the truth of religion, but just as certainly all of them are efforts to find the truth; and since nothing is more real than effort, we must regard even contradictory dogmas as being manifestations of truth.

Science has perhaps set the example of careful, logical thinking from cause to effect, or from effect back to the cause. Emotional manifestations are not so easily defined as material manifestations and in religion we have a far less definite point from which to start our process of careful thinking. Nevertheless the great religious teachers have been deep thinkers, and it is only by thinking that man can understand more of his religious nature. The material world is inseparable from the spiritual. One cannot understand one and ignore the other. Science and religion have a common cause, to *try* to understand ourselves, and real progress can be achieved when they work in harmony, supplementing each other. The real scientist ought to be deeply religious, and the religious teacher ought to have a deep appreciation of science. One may even venture the prediction that the human intelligence, in spite of its limited means of perception, may be able some time to demonstrate that spiritual and material forces are not so distinct as we now suppose, but that they are different kinds of manifestations of the same ultimate power of the universe. I have perhaps stressed the importance of understanding ourselves as being the aim of religion and science. But the importance of such an understanding lies in the way that we make use of it in determining our conduct.

Both religion and science teach that self-restraint, fidelity, honesty, industry, and love bring good, and that excesses, infidelity, dishonesty, sloth, and hate bring evil. Science reaches this conclusion by observation of cause and effect. Christ was a careful observer and a deep thinker and we may be sure that the precepts which he has given us were a result of his deep insight into human nature.

Is science in harmony with religion? The purpose of both is to find truth and promote the good in the world. Certainly their aims are harmonious. The method of science is that of careful observation and careful correlation of cause and effect; surely this method is in harmony with any reasonable religion. Scientific knowledge, it is true, has been applied for evil purposes, just as crimes have been committed in the name of religion, but this does not stamp either as being bad or antagonistic to the other.

Apparent contradictions are abundant in this world and it is not surprising that many people see contradictions between science and religion. But science has gone far enough to show that things are not what they seem, that the material things which happen to make the strongest impression on our sensations are no more material than smoke rings or ripples. A radio receiving set is tuned to receive messages of a certain wave length, while other wave lengths pass unperceived. Our senses of perception of natural things are tuned to receive impressions from only certain kinds of manifestations, but who can tell what may not exist that our sense organs are not tuned to receive. Science is therefore in no way antagonistic to religious belief in spiritual life after mortal death.

But if one reads, for example, the Bible account of the creation literally, one finds it to vary a good deal from the account of creation which the geologist finds written in the earth's crust. Perhaps the laws of nature have changed since that time and geological epochs were actually crowded then into seven successive days. If any one of you finds comfort in believing that the earth was created in seven days you are entitled to that satisfaction; but if you want to force others to adopt the same belief, I ask you to contemplate the fact that you are one individual of the millions who believe in the Bible, that many of those millions regard the account of creation as expressed in symbolism rather than in terms of literal fact. I ask you to further contemplate the fact that the great majority of the world's population profess a different religion than yours. Have you cause to consider yourself more enlightened than all the others? Furthermore, I ask you to consider that all the world's religions are essentially good. If one studies their holy writings he finds that they all possess very much the same spirit, differing in the symbolisms they use, but coming to pretty much the same sort of conclusions.

There are narrow-minded scientists and there are religious bigots who cannot rise above trivial differences of opinion, but we mention them merely to dismiss them. We are concerned with those who have beliefs which they have acquired through earnest effort, who are steadfast in those beliefs while respecting convictions of others. In the lives of people of this kind, science and religion are both necessary factors, never antagonizing but always supplementing and supporting each other.

RECENT DEVELOPMENTS IN THE USE OF X-RAYS

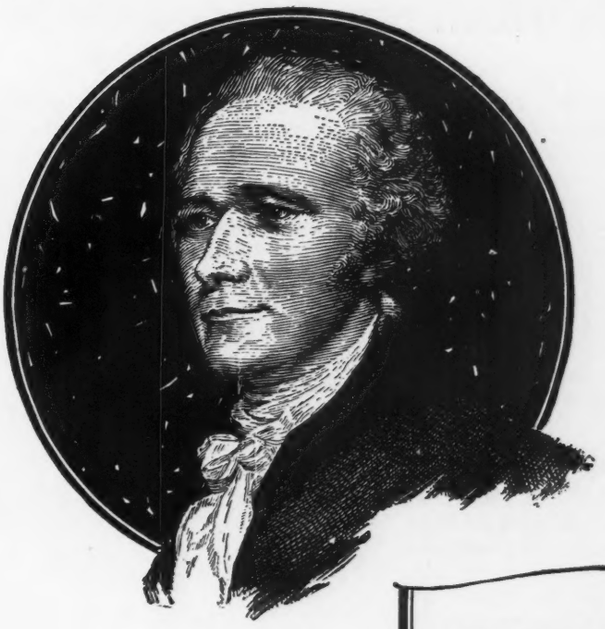
(*Continued from page 91*)

of X-rays in the operating room itself as an aid in the manipulation of fractured bones, or in the extraction of foreign bodies.

Many instances occur in which it is hardly possible by an ordinary clinical examination to tell just what has occurred as a result of an injury. It is in these cases of doubtful nature that the X-ray picture comes to the rescue of the surgeon. Typical of this are cases involving sprain and dislocation which are usually difficult to diagnose, especially when the injury has been severe enough to cause a large amount of liquid effusion into the surrounding tissues.

Parallel to the rapid technical development of X-ray apparatus has been an increasing knowledge of the value

(*Continued on page 104*)



For the man beyond the campus

FOURTEEN YEARS AGO Joseph French Johnson, who was, and is, Dean of the School of Commerce, Accounts and Finance of New York University, found himself faced with a problem to which there was no satisfactory answer.

He was constantly in receipt of letters from business men, many of them occupying places of executive responsibility. The letters asked such questions as these:

"What books shall I read?"

"Can you lay out for me a course in business economics?"

"How can I broaden my knowledge of salesmanship, or accounting, or factory management, advertising or corporation finance?"

Those were pioneer days in the teaching of Business. Dean Johnson, wanting to help, yet feeling keenly the lack of suitable facilities, conceived the plan of a faculty including both college teachers and business men, and a Course so arranged that any man might follow it effectively in his own home.

Thus began the Alexander Hamilton Institute. Dean Johnson has continued as its President; its Advisory Council includes these men: JOSEPH FRENCH JOHNSON, Dean of the New York University School of Commerce; GENERAL COLEMAN DUPONT, the well-known business executive; PERCY H. JOHNSTON, President of the Chemical National Bank of New York; DEXTER S. KIMBALL, Dean of the Engineering Colleges, Cornell University; JOHN HAYS HAMMOND, the eminent engineer; FREDERICK H. HARDMAN, Certified Public Accountant; JEREMIAH W. JENKS, the statistician and economist.

To young men of college age, the Institute says: "Matriculate at a college or university if you possibly can; there is no substitute for the teacher." To older men, the universities and colleges, in turn, are constantly recommending the Modern Business Course of the Institute.

It is a Course for the man beyond the campus; the man who is already in business and cannot leave, the man who wants to supplement his college education. If you are such a man, may we send you, without obligation, a copy of "Forging Ahead in Business"? It tells how 200,000 men have profited by a business training founded upon university principles, and conducted in accordance with university ideals.

THESE COLLEGES and universities, and 80 others, have used parts of the Alexander Hamilton Institute Course in their classroom work.

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Bucknell University
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Massachusetts Institute of Technology
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New York University
Northwestern University
Ohio State University
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Trinity College
University of Alabama
University of California
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University of Texas
Vanderbilt University
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Washington and Lee University
Williams College
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Alexander Hamilton Institute
814 Astor Place, New York City

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RECENT DEVELOPMENTS IN THE USE OF X-RAYS

(*Continued from page 102*)

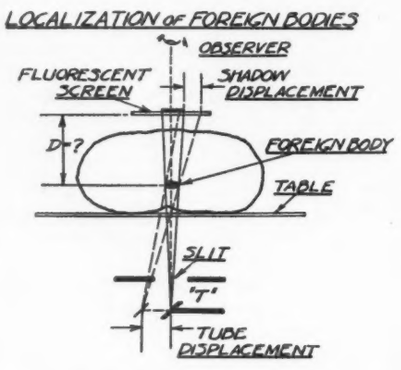
of X-rays in purely medical diagnosis. Of the greatest importance are the studies on the heart, lungs, and the digestive tract. By using relatively soft rays, sufficient differentiation may be obtained in the soft tissues to make possible the detection of even slight abnormalities. When the radiation is of great intensity radiographs may be recorded in one one-hundredth of a second and with such short times of exposure great photographic detail is possible, since the effect of motion then becomes negligible.

The shadow images obtained in a dark room on a fluorescent screen are always more or less hazy in detail as compared with those of good radiographs. However, the fluorescent screen is invaluable in the study of motion, particularly that of the heart, and also in instances where an immediate report is necessary.

Through the necessary fundamental training and with long experience, the X-ray specialist becomes familiar with the shadow characteristics of the normal anatomy. He is enabled thus to render a very definite opinion in those cases involving enlarged heart, defective heart action, pulmonary tuberculosis, pleurisy, diseases of the digestive tract and kidneys.

While observations on the heart and lungs and kidneys are made with but a minor amount of preparation on the part of the patient, it is ordinarily impossible to define the digestive tract at all satisfactorily, due to the fact that the contents of the abdomen are physically of nearly the same density and general character of absorbtive power. If, however, some substance opaque to X-rays, such as bismuth carbonate in suitable suspension is taken by mouth, the passage of this mixture through the digestive tract may be recorded. When a sufficient dose of the suspension is given (which is about one pint), the outline of the stomach and the intestines becomes clearly visible. In this manner, ulcers of the stomach are often definitely located. The study of the digestive tract by means of these opaque "meals" has become so important that it constitutes a specialty in itself. Usually a diagnosis is generally made from a large series of rapid radiographs, supplemented by observations with the fluorescent screen.

It has been stated that X-rays have the property of affecting living tissue. This effect is cumulative, and depends almost entirely upon the amount of radiation received. Short exposure to the rays, such as is experienced during the making of radiographs, seems to be entirely harmless, and a greater dosage will serve only to stimulate the tissues, while still longer exposure will produce a more or less severe burn, with the resultant death of some of the cells. Fortunately, the tissue composing most abnormal growths, such as that found in cancer and many common skin diseases, is relatively more sensitive to the rays, and



may, in consequence, be subjected to a selective treatment. The dosage used must be such that the diseased tissue is killed, and yet at the same time allow the normal tissue to remain unharmed. Since the ultimate effects produced by X-ray treatment are not apparent for a period of several days after the time of exposure, the dosage which is applied in any given case must be controlled with extreme accuracy. Prior to the development of the Coolidge X-ray Tube, the amount and kind of radiation produced by a tube could not be determined with any degree of exactitude by a simple adjustment of the tube current and voltage. It was known, however, that a given amount of radiation would produce a definite color change in certain crystalline substances, of which barium platino-cyanide is an example. By means of an arbitrary scale of color standards, it is a simple matter to measure X-ray dosage, providing the operator is not color blind. The reliability of the Coolidge Tube, however, is such that the characteristics of the radiation produced may be determined accurately by fixing several operating conditions. Thus the troublesome method of measuring dosage by means of color standards is no longer used to any extent in this country, at least.

The X-rays generated by any tube are not of one wave length, but have a spectrum analagous to that of the visible rays, and covering a comparatively greater range of wave lengths. The proportionate composition of the radiation may be varied by altering the terminal voltage of the tube. For example, if it is desired to obtain a relatively large proportion of "soft rays" such as would be used in the treatment of skin disease, the tube would be operated at a low terminal voltage. "Soft rays" are those of long wave length, and possess the greatest therapeutic value inasmuch as they have low penetrating power, and are in consequence entirely absorbed by the skin and upper layers of tissue.

In the treatment of cancer, the focus of which often lies far below the surface of the skin, it is obviously necessary to reach effectively these deeper parts, without, at the same time injuring the overlying tissue. The desired result is obtained by the use of a "filter" which is simply a sheet of aluminum usually one half to three millimeters in thickness. This filter absorbs all of the "soft" radiation which would be harmful to the skin, but allows the "hard" rays to pass through and act on the cancerous tissue below.

In the course of any systematic treatment of disease by X-rays, the unaffected parts are protected by means of lead sheet or other material of suitable absorbent quality. The operator, who is subject to exposure continuously, must take every reasonable precaution against burns. Failure to do this has resulted in the death of at least several of the early investigators, who were unaware of the dangers attendant upon prolonged exposure to the rays. To these men, who truly gave of themselves, humanity owes not an inconsiderable amount of gratitude. All X-ray machines of recent design afford ample protection to the operator so that there is no longer any particular hazard connected with this work.

The impression that X-rays are an entirely effective means of cure in the treatment of cancer, for instance, is erroneous. While many cases of positive benefit have been recorded and medical research in this field has been most promising indeed, the science of treating cancerous growths with both X-rays and radium rays is still in a laboratory stage. Certain skin diseases, however, such as ringworm, may be cleared up with certainty by relatively short and inexpensive treatment. A dosage of rays is rarely given at one time, but is generally distributed over a period of several months. This allows for some recovery of the normal tissue, and also prevents any great overdosage being given.

ENGINEERING—before the bids are opened

EVERYONE appreciates that considerable engineering must be done after an order is received for a fire alarm central office but few realize the extent of the engineering required before the bids are opened.

Fall River, Mass.—a $185,000 contract is typical of several recent installations. It was necessary first to determine the location of the two hundred and fifty boxes, many of which were to be relocated. The number of box circuits had to be determined and the location of the cable terminal boxes decided upon. The amount of cable to be pulled in, aerial wires to be run and length of lateral placed, all had to be determined. Provisions had to be made for the traffic signal circuits and independent telephone circuits to the offices of the fire department and to the various engine houses.

A map showing the location of each box and terminal with the routing of the cable, number of conductors and length of wire was submitted together with the individual lengths of the various laterals.

The complete job consisted of a new central office in an isolated building; replacing all the old style street and industrial boxes and installing boxes on all schools. Ninety-eight reels of cable were ultimately required and many many miles of aerial wires strung.

Definite knowledge has replaced "rule of thumb" in the fire alarm industry just as it has in every industry which the engineer has entered.

The Gamewell Fire Alarm Telegraph Co.

Newton Upper Falls, Mass.

**FIRE ALARM AND PUBLIC SIGNALLING SYSTEMS
FOR MUNICIPALITIES, INDUSTRIALS
AND INSTITUTIONS**

WATER-COOLED THERMIONIC TUBES FOR HIGH POWERS

(*Continued from page 89*)

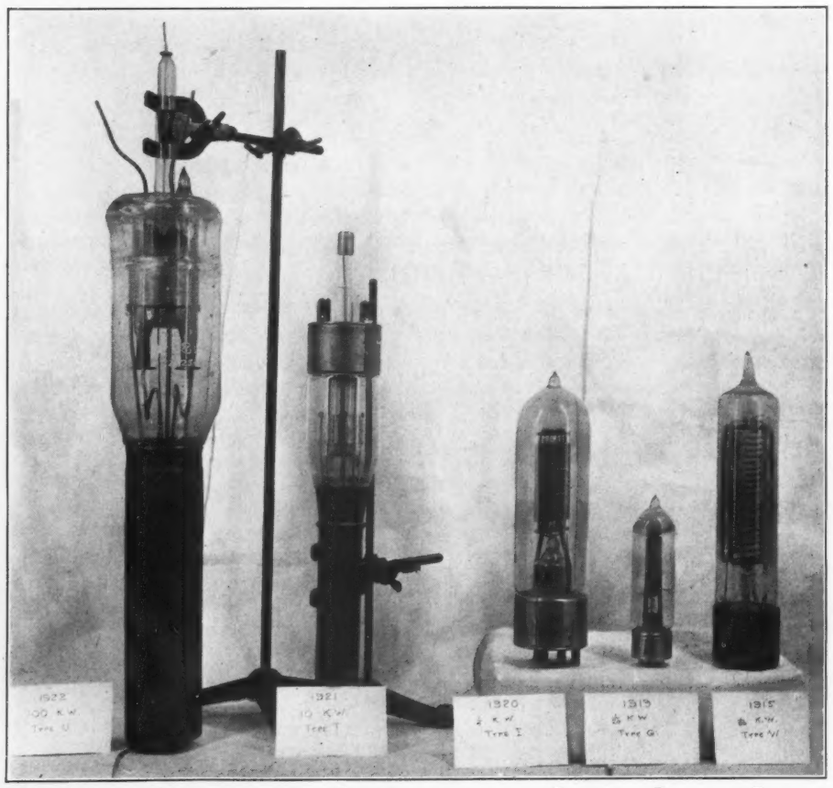
For example, a seal at room temperature may be placed directly within an oven at 450 degrees C. without failure of the seal, and it may be removed from such a chamber after having attained the temperature of the chamber without damaging the seal.

Seals of the same general sort are used for conducting current to and from the filament within the tube. It consists essentially of a thin copper disc through the center of which passes a copper wire. The wire and disc are soldered together. Glass is melted to both faces of the copper disc, to one face of which a glass tube is attached. In this type of seal the copper, immediately after assembly with the glass, attempts to contract radially, the resulting stress being impeded in the same manner as stated above. With this impeded contraction the copper contracts in thickness by such an amount as to make up for the lack of radial contraction. A copper disc which is one inch in diameter, cold, will, after having been assembled with glass and again cooled, measure approximately .003 inch larger in diameter.

A curious and valuable feature of such seals will be apparent on further consideration. When the seal is cooled the copper disc is in radial tension and the glass under compression. With sudden application of heavy current to the conductor, strains due to expansion of the copper with heat first pass through zero and then become strains of compression in the copper; that is, sudden application of heat to the wire actually reduces the stresses in the seal rather than increases the stresses as in the ordinary form of platinum seal. Further, such seals will continuously carry currents sufficient to maintain the copper wire red hot in air. For example, a No. 6 B & S gauge copper wire normally carrying 90 amperes will continuously carry 550 amperes in air, at which current the wire is approximately 800 degrees C. The seal will remain tight without failure of the glass.

By the same means it is quite possible to seal metals other than copper with vitreous materials other than ordinary lead glass. For example, seals have been successfully made between pyrex glass and copper and platinum. Brass, iron, nickel and silver have been successfully sealed through lead glass.

While this description has applied particularly to the 10 kilowatt tube, a number of which were recently used in trans-Atlantic radio telephony, further advances have been made in tube design. Figure 2 shows the advance made since 1915. E. is a 40-watt tube used in the Arlington-Paris-Honolulu radio telephone experiments of 1915. D shows a 50-watt tube of present-day design used in small broadcasting stations. C shows a 250-watt tube used in standard broadcasting stations. B shows the 10 kilowatt tube whose construction has been described, and A shows a 100-kilowatt tube constructed along the same lines as the 10-kilowatt tube. This last tube operates at 20,000 volts. The copper anode measures approximately 3½ inches in diameter by 14 inches long. The filament requires approximately 5½ kilowatts to maintain it at operating temperature. The tube stands approximately 32 inches high overall. It is expected that only a very few of these 100-kilowatt tubes will be required for the longest distance transmission likely to be needed in the future.



A B C D E

FIGURE 2

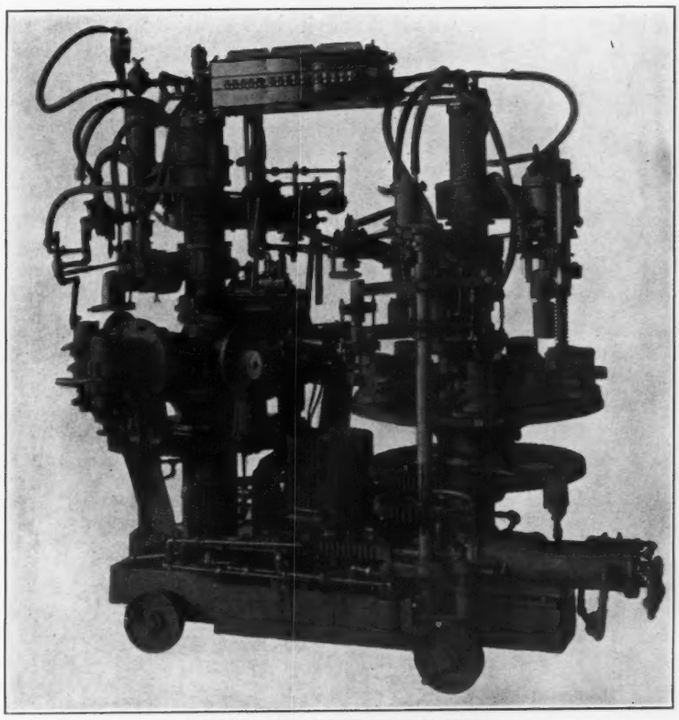
Pure Malleable Nickel. Owing to the difficulties encountered in shaping and fabricating ninety-nine per cent pure nickel, nothing much has been done towards the development of this metal in the forms necessary for commercial use. But the widespread interest manifested in the production of a non-corrosive, heat-resisting, easily machined metal led Dr. Charles T. Hennig to continue his experimental work for many years. The result of this research is a metal which submits to rolling, forging, drawing and piercing as readily as mild steel.

The ore is obtained in the Sudburg district of Ontario. The steps in its preparation are the sintering, roasting, smelting, and the formation of the matte. The matte, consisting of a mixture of about equal parts of nickel sulphide and copper sulphide with a small percentage of iron, is refined by the carbonyl process.

The final product of this process is nickel shot about 99.8 per cent pure nickel. This is charged with scrap in special open-hearth furnaces, which gives it malleability, after which it is poured into ingot or slab molds. These slabs are broken and rolled in a similar manner to steel.

The final product may be mechanically worked into finished shapes heretofore considered impossible. Following is a list of properties of this metal:

	Hot Rolled Lbs.	*Cold Rolled* Lbs.
Tensile strength...	8,500	100,000–150,000
Elastic limit.....	55,000	80,000
Yield point.....	65–70,000	100,000–125,000
Elongation in 2 in.	50%	10–35%
Reduction in area	70%	20–65%
Melting Point.....	1485°C, 2705°F	
Specific Gravity...	8.35	



A MODERN BOTTLE MOLDER

Engineering Skill and the Glass Bottle

A GLASS BOTTLE, at first thought, seems a relatively simple thing; yet how infinite have been the experience and inventive skill back of its manufacture.

Years ago, highly trained men labored hard and long to produce even one bottle. Today, engineering skill, fostered by companies interested primarily in bettering the industry, has made possible the rapid production of better goods — at a greatly reduced cost. Again, to the old bottle-blower, clever and variable finishes were unknown and only the finest workers were able to produce bottles of other than standard shapes and sizes. Now, colors ranging from the deepest emerald green to the clearest flint, with finishes varying from the regular American to the unique K. N. S., are readily obtainable for any shape or size of bottle. It is these tremendous advances that have given the glass bottle industry the essential position it occupies in our present-day life.

Foremost among American bottle manufacturers for generations and outstanding in its contributions to the industry has been the SALEM GLASS WORKS. High standards of quality, perfect service and absolute integrity have always been the aims of this concern. Establishment of them has placed the Company in the high position it occupies today.

SALEM GLASS WORKS

SALEM, NEW JERSEY

Nothing is impossible when it comes to giving better service and making better goods

WATER DISPERSIONS OF RUBBER COMPOUNDS

(*Continued from page 90*)

In the application of natural latex to papermaking, no curve could be plotted to show an increased strength or folding index, in relation to quantity of rubber incorporated in the stock. In fact when over two per cent of rubber was present in the finished sheet, a marked falling off of both these factors was noted. Further than this, the oxidation of such limited quantity of rubber as had been incorporated with the pulp produced constantly changing factors, which made it impossible to give any assurance of permanent application to the art of papermaking.

The record of this work with tabulated results may shortly be available for publication. It has been most thoroughly carried through to a conclusion, in spite of the discouraging possibilities in relation to the use of a natural rubber latex in this art or the substitution for same of a dispersed rubber.

The other commercial application was presented in connection with the use of a natural rubber latex for cloth treatment. That is to cotton goods, particularly where further rubber coating was to be applied, this coating to give a rubber anchor to skim coats of rubber compounds as applied to such fabric. The test work covering this has been carried out with like care and attention to records, both of chemical and physical results.

We had hoped that the sulphur from the compounds, as applied to rubber latex treated fabric, might migrate through to this finely incorporated rubber which had been introduced through latex treatment, and effect cures which would at least equal those secured by the application through the spreading of solvent compounds of crude rubber. From our tests we were again doomed to disappointment. Results were neither uuiform nor promising. Here, again, snch data as has been secured must be left for later publication.

It is a fact that had we not begun work, which from the start pointed to a successful conclusion, in relation

(*Continued on page 110*)

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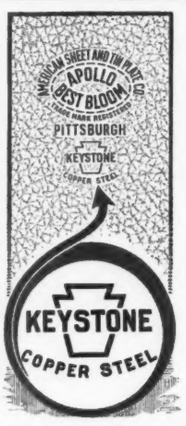

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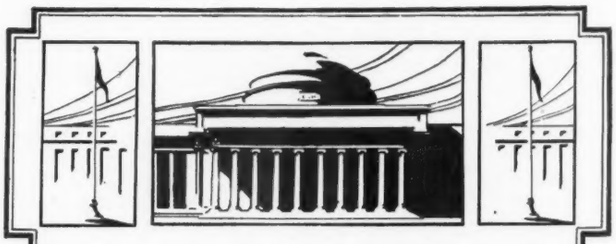

WE WANT YOU TO KNOW US BETTER

The undergraduate publications of the Institute, THE TECH, THE TECH ENGINEERING NEWS and THE VOO DOO are offering to the alumni a group subscription to the three publications for the purpose of promoting a closer relationship between the alumni and the undergraduates.

THE TECH, published tri-weekly, contains all the graduate and undergraduate news of the Institute.

THE TECH ENGINEERING NEWS, the professional journal of the alumni and undergraduates, is published monthly for the purpose of disseminating news of scientific and industrial interest.

THE VOO DOO is the monthly humorous publication of the Institute, and is published eight times during the scholastic year.

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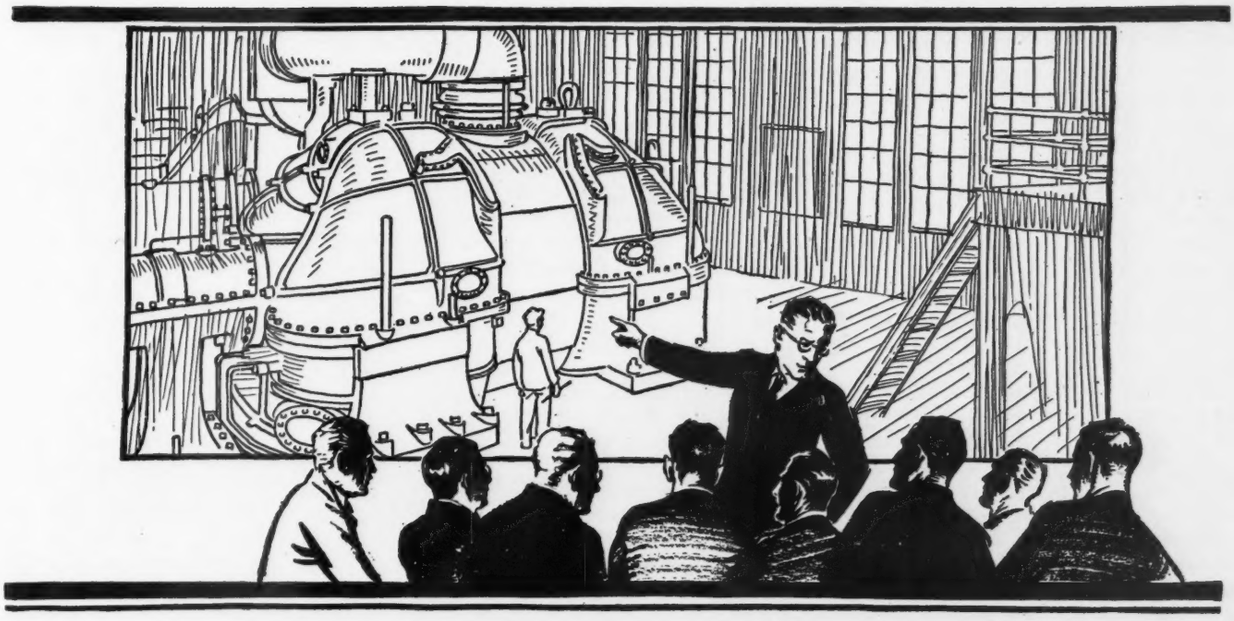

The University of Engineering

Of all the things that go to make the successful engineer, none is more important, nor more in step with the spirit of the profession, than a studious attitude. One man says about another—"he is always willing to learn," "he doesn't think he knows it all"—and he intends to pay a high compliment when he says it.

The great engineers are always at school, always learning, always seeking for more knowledge. They begin with this desire for fuller understanding, and they keep it up to the end.

Any engineering operation, over and above the primary purpose for which it is carried out, is an active and post-graduate class in engineering, also. So that Westinghouse, or any other great business, is, of its very nature, a University where theory and practice combine to make bigger, broader and more practical engineers.

The courses in this University are not limited to prescribed subjects nor terms—the subjects are almost infinite, and the semesters are endless. Men with the weight of years on their shoulders work and learn side-by-side with those whose day has just dawned.

This post-graduate school fits men for almost anything. Fits them for it, and makes them continually fitter. Out of this continuing fitness have grown the engineering accomplishments on which this institution has grown. It is, perhaps, one of the great educational institutions of its day.

Westinghouse

ACHIEVEMENT & OPPORTUNITY

WESTINGHOUSE ELECTRIC

WATER DISPERSIONS OF RUBBER COMPOUNDS

(*Continued from page 108*)

to the dispersion of rubber compounds, we would have dropped the entire subject as one too problematical in relation to commercial returns to warrant further expenditure of time or money.

Nature did not, could not, foresee the application of rubber to the great industry of today, when producing the latex for its own economic use. Goodyear introduced sulphur to rubber, giving it a life, strength and lasting quality which has made possible the evolution of this industry.

Whether in a friction compound, or as a spreading medium in solution with a solvent, sulphur must be present if application of rubber to fabrics is to be of permanent value. Further than this, compound materials with accelerators, for the shortening of cures and the proper combining of the sulphur with the rubber, must be added if modern factory practice and efficiency of production are maintained. Herein nature has given the research chemist a chance for existence. We have to go further than nature in development of her own products, if we are to meet commercial evolution.

It is in relation to this work, — the dispersion of rubber compounds, — that we hope to give to the manufacturer who would use rubber either in paper or fabric treatment, an impetus to develop products having new application, under better factory practice and control. It would seem to promise the abolition of fire hazard in factory application from use of inflammable solvents, as well as the injurious effect on workmen through inhaling of fumes. The costly friction calender, with its overhead expense, and exacting supervision in order to avoid damage to the goods, seems to be possible of elimination.

We have succeeded in making dispersions of rubber compounds from any "friction stock," concentrating the rubber content to almost any desired extent for special application. The consistency of these water dispersed compounds can be applied by the use of a simple spreading machine, to a gauge equivalent to those secured by the use of a friction calender and application of a skim coat. These compounds carry the accelerator in a uniform and satisfactory manner. Such compounds, cured in the same press with samples made by regular methods of present factory practice, have shown the same factor of vulcanization, and fully as high physical results, such as strength of friction pulls, etc.

In summing up the results secured from this work, we feel that water dispersions of rubber compounds will mean to the manufacturer that he can use the formulae which he has already established to the satisfaction of his particular production; that he may find possibilities of new compounds because of fewer limitations of exactitude in relation to application. These compounds would be prepared exactly as is now his factory practice, but after milling they would go to the churn for water dispersion. Simple mechanical equipment would permit of securing rubber concentrates dispersed in water, which would enable him to apply this rubber with all the exactness of present control, but with the use of inexpensive equipment which would require far less care and with less attending risk of injury to the goods, than is possible under conditions of present production.

Cooley & Marvin Company

Boston Chicago

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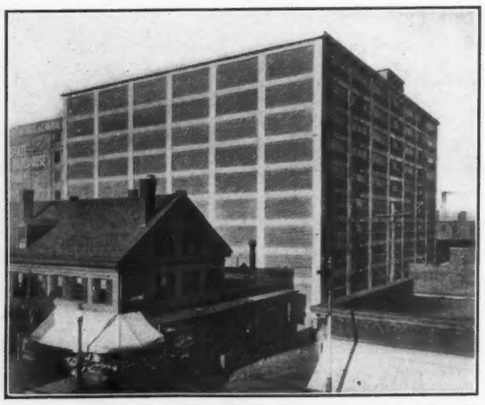

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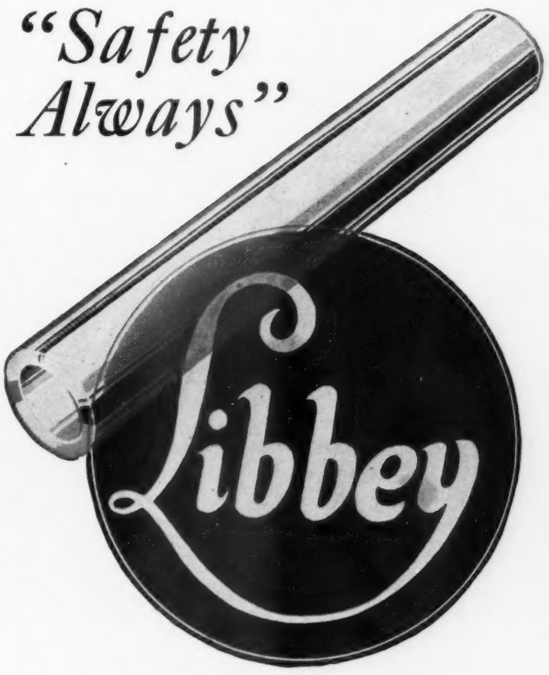

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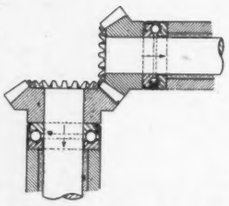

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THE 1923 THESIS

(Continued from page 93)

of concrete. B. Gasser is experimenting to see if there is a relation between the compressive strength and the tensile strength of Portland Cement mortars. This is in line with several other theses which take as their subjects reinforced concrete buildings of various sorts. T. J. Hills is designing a warehouse and H. Kalker and H. N. Liesk are designing a factory building while W. S. LaLonde, Jr., and G. G. Walker are designing a garage. This seems to indicate that reinforced concrete is the coming building material, a belief that is partially offset by P. S. Rice who is making comparative designs for a warehouse to be made of either wood or steel.

Bridge design and construction is being investigated by A. Canzanelli who is designing a highway bridge across the Mystic River in Medford; by B. Elosua who is designing a reinforced concrete highway arch bridge and by P. V. B. Heiss and C. D. Dippel who are designing a two hundred and fifty foot single track through truss railroad bridge. This leads us to railroad work which is represented by L. H. Poor, who is working on a scheme for the improvement of public freight facilities of the Pennsylvania Railroad; N. Lassen, who is making a study of the existing automatic train control mechanisms and compiling the requirements of such a system; and D. R. Dresel, who is planning the installation of automatic block signals on the Central Massachusetts railway.

Other transportation projects are being taken up also. R. E. Hendrie is making a very interesting study of the improvement of Soldiers Field Road in Cambridge, Massachusetts. This is a very much needed project as the road at present makes a three-quarter turn on one direction and then a quarter turn in the other direction, making it dangerous to automobilists who use it. N. Page is investigating the location and cost of a highway between Fellsway East and Washington Street in the Middlesex Fells.

Drainage and sewerage problems are being taken up by J. M. Robbins and A. C. Stewart, who are designing a system of sewers for the Lakeview district of Waltham, Massachusetts and another design for a sewer system by J. R. Fisher for the western portion of the town of Canton, Massachusetts.

(Continued on page 114)

Safe Walkway Surfaces

The American Institute of Architects
are preparing a National Safety Code for Safe Walkway Surfaces under the rules and procedure of the
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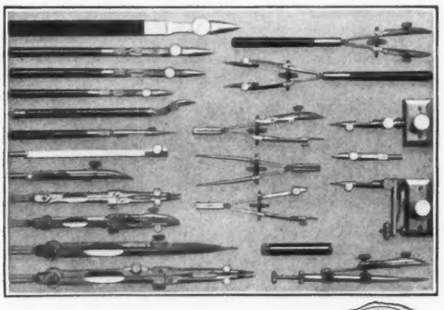

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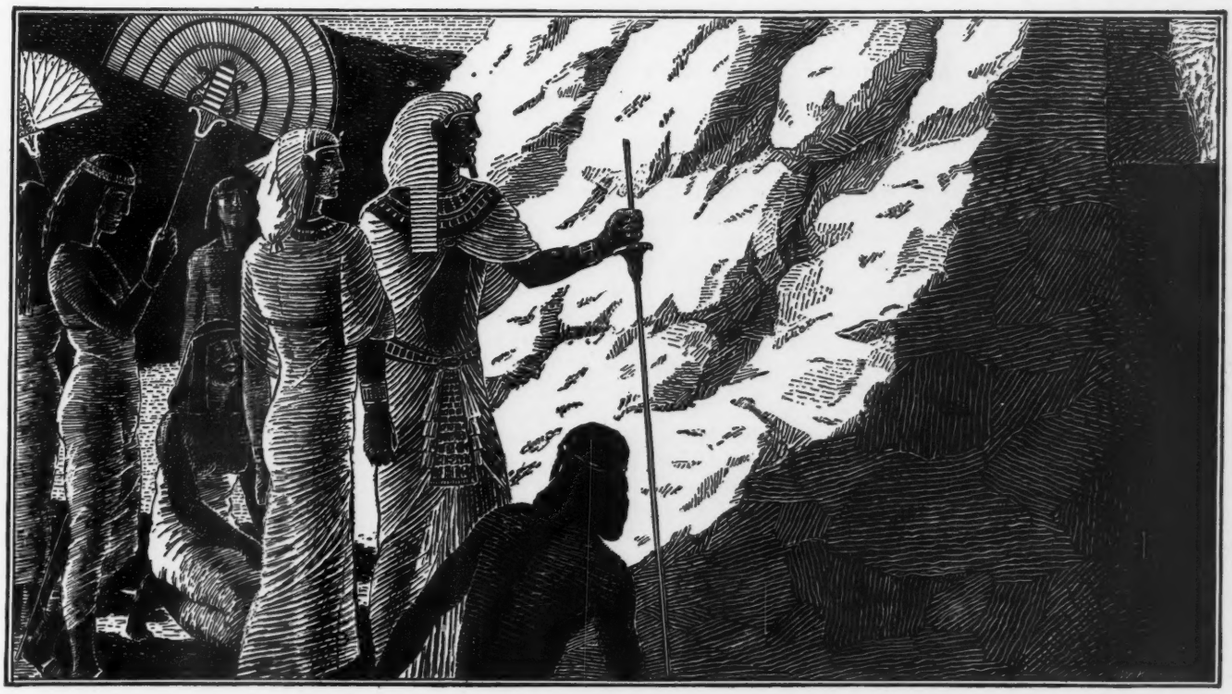

The Tomb of Tutankhamen

More than three thousand years have passed since Tutankhamen supervised the construction of his rock-hewn tomb. After he died, his paraphernalia of pomp and pleasure, war and worship, were laid away with him, because in those days the tomb was regarded as the eternal abode of the soul.

In Tutankhamen's time, gold, silver, copper, lead, and tin were mined; bronze vessels and tools were wrought and cast; large blocks of stone were quarried and long underground passages were driven.

These early Egyptians broke rock by driving wooden wedges into grooves chipped out with bronze tools. The swelling of the wedges, after they were wet with water, was sufficient to crack the stone. Thus they tunnelled the tomb of Tutankhamen.

The Pharaohs of Egypt had countless slaves at their command. Therefore, they disregarded labor costs. Far different is the situation of the modern miner, quarryman, or contractor. Now, even the concentrated energy of dynamite—the great labor-saver of this age—must be carefully conserved.

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Our booklet, *Volume Vs. Weight,* contains complete information on Hercules Special No. 1. Our general catalog is called *Hercules Products.* Write to our advertising department, 939 King Street, Wilmington, Delaware, for free copies.

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THESIS

(*Continued from page 112*)

Mining Engineering is a branch of engineering which most people know very little about, but it is a very important one. This year several new projects are being investigated. One, by L. F. Buch and N. L. Weiss is on a method of differential flotation for ores. Another, by M. L. Carey and S. W. W. Sullivan is the extraction of aluminum from clay and slate. The rest of the theses are mostly investigations of mines for their possibilities for profitable working or some particular district with regard to its value for mining purposes.

Two chemical engineering theses are of great interest because of their newness. "The Investigation of the Effects of Oxygen in Tap Water" is one of these. Oxygen is dissolved in the tap water as the result of long contact with air in reservoirs. Pipe corrosion is largely due to this dissolved oxygen in the water. In this experiment it is attempted to reduce the oxygen content by the deposition in it of electrolytic hydrogen. The author of this thesis is E. T. Allen. The other one deals again with automobiles. It is "The Effect of Crank Case Dilution." The attempt is being made to determine the effect of, other than a decrease in viscosity, the dilution of crank case oil by fuel. Determination of variation of wear and in the property of oiliness with the dilution are being made.

Physics is another abstract science, but four of the subjects this year are very plain. Mr. Bastille's already mentioned is one of them. T. M. Edison is making a test for molecular magnetic groups in iron, R. W. Conant is investigating the melting point of silica and W. B. Greenough, Jr., and B. E. Warren are studying the frictional electrification of gasoline.

There are many more equally interesting. The field of higher degrees has not been touched. There will be nearly two hundred degrees higher than that of Bachelor of Science awarded in June. None of these have been told about, as they are for the most part too technical to mention here. Only a few of the bachelors' theses have been covered. To anyone who goes through the laboratories and the libraries where the seniors are at work upon the culmination of their Tech training, it will be evident that this article has been only too brief to do justice to its subject.

Determination of Sulphur

We recommend the Hinman-Jenkins Apparatus for the accurate determination of sulphur in illuminating gas.

Combustion of the gas takes place at the base. Condensation is secured in the upper section, and the liquid collected in the small flask.

The simplicity and sturdiness of this apparatus make it especially valuable in traveling inspection work.

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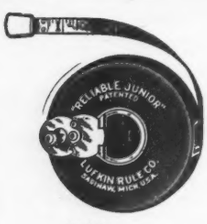
The Engineering College Magazines Associated

An organization of the eighteen leading college technical journals of the country; it was founded for the purpose of raising the standards of college engineering journals and in this way serving to better advantage the alumni and undergraduate engineers, and the advertisers desiring to reach this field.

There are *twenty-five thousand* subscribers eager to know all about the latest developments in commercial engineering to whom no better or more pleasing approach can be made than in their own college magazine. There are *fifteen thousand* student subscribers anxious to know and understand the concerns they will be affiliated with when they graduate.

THE TECH ENGINEERING NEWS, as founder of this group, stands ready to coöperate with any engineering concern desirous of reaching the most fertile field of potential users of engineering equipment ever brought together for the service of the advertiser.

The same advertisement on the same size page appears at the same time in eighteen college technical journals



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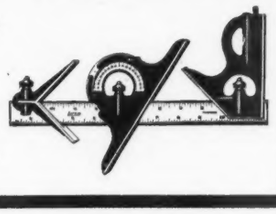

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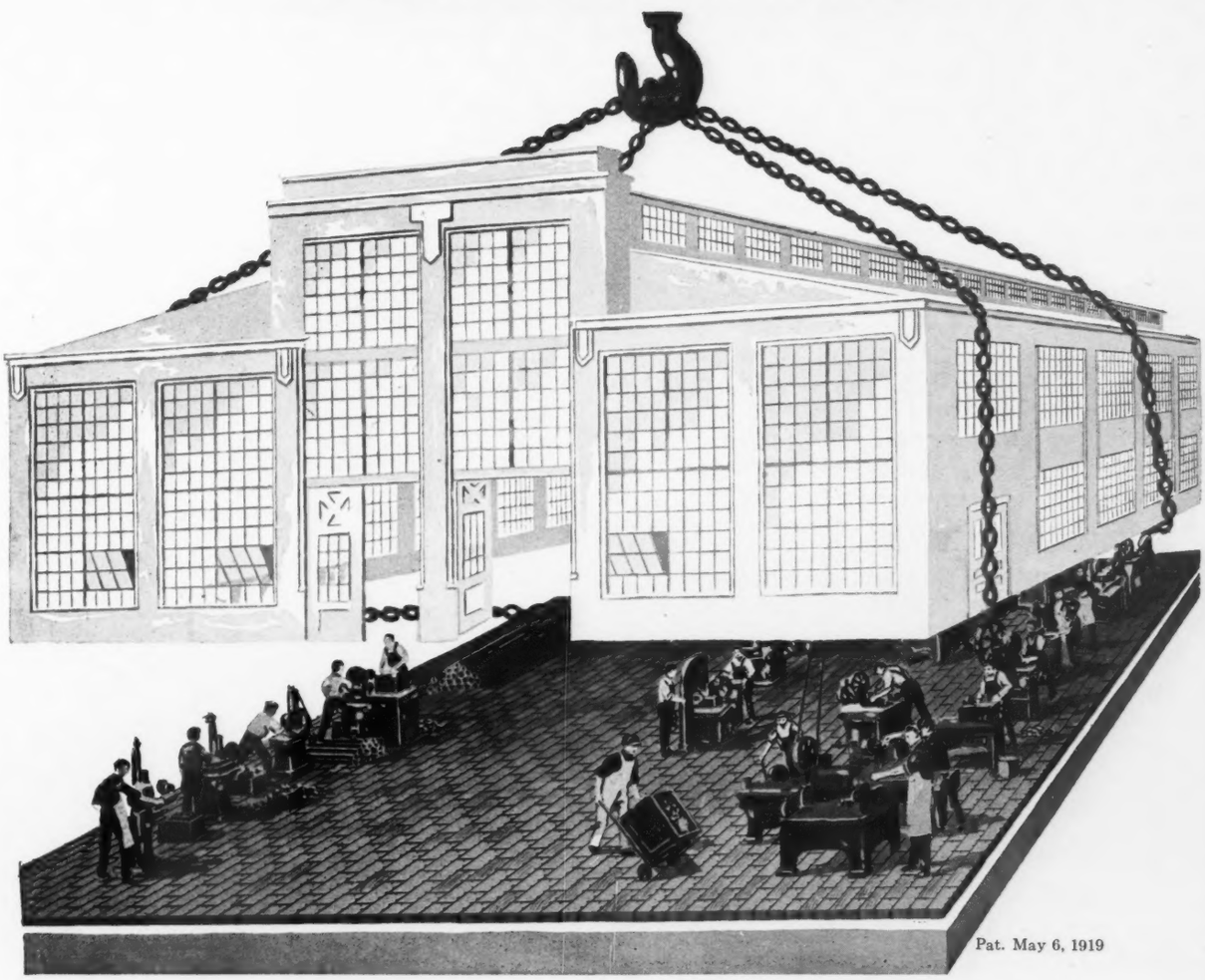

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The Floor is the *Producing* Part

Remove the factory side walls and roof — you do not **stop** production — you simply **expose** it to the elements and outside distractions.

On the floor of the factory machines hum, men labor, products move along to completion. And the expedition and economy with which they move is governed entirely by the floor **assistance** or **resistance** encountered.

Kreolite Wood Block floors are fast displacing other types.

All kinds of manufacturers have found no other material so permanent, so resilient, so saving and so helpful to men, machines and production efficiency.

Kreolite's patented process, by which the blocks are impregnated with Kreolite Preservative Oil, makes them impervious to moisture from above and below. And its exclusive design provides grooves which, filled with Kreolite binder pitch, make the floor a single unit of such durability that it **outlasts the factory.**

Kreolite Wood Block floors are especially adapted for use in machine shops, foundries, paper mills, tanneries, loading platforms, and stables.

Our Factory Floor Engineers are ready at all times to co-operate fully, without obligation. Send for our service or write for our book on Kreolite Floors. Write the Toledo Office.

The Jennison-Wright Company, 86 Kreolite Building, Toledo, Ohio

APPLICATIONS OF LIGHT WAVES TO MEASUREMENTS

(*Continued from page 88*)

of about one part in six million, and if all of the forty meter bars in the world were destroyed we could again have the same standard with the aid of unchangeable l ght waves. The number of wave lengths of light between two glass optical flats wrung on the ends of a gage block may be determined and thus its length is known. This is a somewhat complicated procedure and is carried out only when it is desired to originate a standard. Such work is accomplished at the National Bureau of Standards, Washington, D.C. It is an easy matter, however, to compare the length of a new or worn gage block with a known standard, and this is now done in many American manufacturing plants.

Both the known gage and the unknown gage are wrung side by side on a glass flat; another optical flat is then placed on the two gages and if they are both the same thickness, the bands on one gage will exactly match those on the other gage. Figure 2 shows two gages very nearly the same length or thickness, but differing by one half band or five millionths of an inch.

The diameter of a ball or cylinder may be easi y measured in comparison with a gage block or a combination of gage blocks. This procedure is shown in figure 3. It is worthy of noting here that the gage blocks and particularly the round gages may be made with surfaces parallel within one- or two-millionths of an inch. Thus the gage block serves to establish a parallel reference plane $\frac{1}{4}'' \times \frac{1}{2}'' \times 1''$ or any other desired distance above the surface of the lower flat. The upper flat rests upon, and is positioned by the gage block and the article to be measured. It is easy then to count or estimate the number of bands from the point of contact of the optical flat on the gage block to the point where the flat touches the article measured. As each band shows a rise of one hundred-thousandth of an inch the amount oversize or undersize of the article measured is at once known. If a mistake of a fraction of a band, or even a whole band is made the error amounts to only ten millionths of an inch.

Another way of looking at the process is to consider the two optical flats as positioned by the gage block and the article measured as a taper gage, with the dark interference bands as graduations of one hundred-thousandth of an inch. Nothing could be simpler. With only two flat surfaces and a gage block standard any piece that is ordinarily measured between the flat surfaces of a micrometer or measuring machine may be easily and more accurately measured with light waves.

The distinct advantage of the light wave scheme of measuring is the simplicity of the apparatus and procedure. There is nothing to get out of order, no micrometer screws, no errors of setting microscopes, none of the many complications that tend to make the measuring slow and susceptible to error. Then again with light waves the standard and the article measured are placed side by side and are observed simultaneously while both are at the same temperature.

The extreme precision secured with light waves is best illustrated by an apparatus consisting of a five-inch diameter solid steel bar with end supports thirty-six inches apart. A gage

(*Continued on page 118*)

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BETTER LIGHTING NEEDED IN INDUSTRIAL PLANTS.

In a paper read before the Illuminating Engineering Society, February, 1920, entitled, "A Survey of Industrial Lighting in Fifteen States," R. O. Eastman submitted some very interesting data regarding the lighting conditions in industrial institutions. The survey comprises some 446 institutions, in which lighting was considered by 55.4% as being vitally important, and by 31.6% as being moderately important, and by 13% as being of little importance. Practically 58% considered that lighting was as important as power in the operation of the plant, and a small proportion would give more attention to lighting than to anything else.

In considering the present condition of lighting as found in the various plants, only 9% ranked as excellent, about ⅓ ranked as good, 29% fair, 18.8% poor, 3.5% very poor, and 7.8% partly good and partly poor. It was found that the lighting in the offices was far superior to that in the shops; 19% being excellent, 36% good, 31% fair, and only 13% poor and none very poor.

On consulting the executives regarding what factors were most important in considering lighting, the following facts were revealed: Increase of production 79.4%, decrease of spoilage 71.1%, prevention of accidents 59.5%, improvement of good discipline 51.2%, and improvement of hygienic conditions 41.4%. Manufacturers who have good lighting appreciated its value largely from the standpoint of its stimulating effect upon output.

There is no question that any intelligent man who carefully considers the necessity for good lighting in an industrial plant, will agree that it is impossible for a person to do as good work, either in quality or quantity, in poor light as in good light, but yet the result of a careful analysis discloses the fact that only about 40% of industrial plants are furnishing good light to their workers and 60% are operating under poor lighting. It is hard to understand why such a proportion of concerns can be satisfied with a condition which is universally admitted to be a curtailer of efficiency and a prolific causer of accidents. The principal cause of this condition is that those in charge of such establishments have not given the attention to lighting that it demands. They do not know what constitutes good lighting, and in their absorbing interest of other factors of production have overlooked a vital one.

Every safety official should deeply interest himself in the lighting of his plant and insist upon good lighting as much as good goggles, good guards and other necessary accident prevention equipment. Every production manager should insist upon good lighting because the efficiency of the working force is increased by the condition of the lighting furnished. The plant physician should examine the lighting, for eye strain and eye fatigue are directly affected by poor lighting, as is the hygienic condition. Well lighted plants are invariably cleaner than poor lighted places. Plants equipped with Factrolite Glass in all windows are well lighted.

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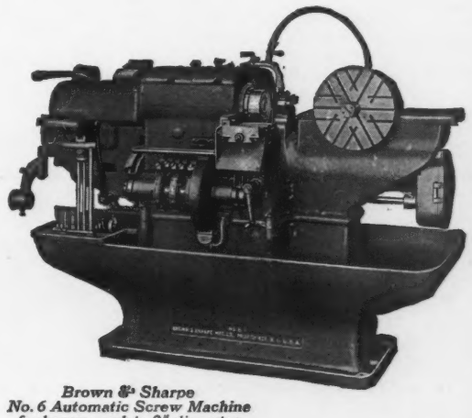

Brown & Sharpe No. 6 Automatic Screw Machine for heavy work to 2" diameter

APPLICATIONS OF LIGHT WAVES TO MEASUREMENTS

(*Continued from page 116*)

attached to the bar, and an optical flat fastened to the channel iron structure above the bar serve to set up interference bands. A slight pressure of the fingers downward on the bar bends the bar downward causing the gage to move away from the optical flat, and the bands move. It is very easy to bend the bar with the fingers to show a movement of the bands two or three times the distance between successive bands or two or three hundred-thousandths of an inch. Also one may press in at each end of the bar and buckle it up or down and note the change of the interference bands.

In measuring with light waves it is convenient to reckon in millionths of an inch or tenths of a unit indicated by each dark band. Thus the hundred-thousandth of an inch is ten millionths, the ten-thousandth is hundred millionths and the thousandth is thousand millionths. It is a new unit of measurement so small that it is hard to conceive. It may be visualized perhaps by knowing that a one half inch steel bar projecting twelve inches from a vise is bent downward approximately one millionth of an inch when a common house fly alights on the end of the bar. Yet withal, this fine unit of measurement is necessary. Gage blocks are now made accurate within five- or ten-millionths of an inch. A plug gage used for measuring holes is worn out when one hundred-millionth undersize, and roughly every ten millionth represents one dollar's worth of the life of the gage. In some factories production is so enormous that several plug gages are worn out each day in measuring the hole in a single type of gear.

FIGURE 1
Straight bands indicate a flat surface. Gage shown in flat within one-millionth of an inch.

There are many possible applications of light waves for industrial requirements and for scientific research. Such problems as the dimensional changes in dental amalgams and cements during setting, expansion and contraction of metals or other substances with temperature or other physical changes, are made easy with light waves. So sensitive is the light wave method in detecting small changes of dimension that a specimen only an inch, or even less, generally is sufficient to secure the desired accuracy of the determination. Thus it will be realized that light waves offer the investigator, the engineer and the mechanic a new and useful tool — one which can be of great service because of its inherent simplicity and ease of application.

Alaskan Coal Development. Coal development in the Matanuska and Nenana fields in Alaska is progressing very satisfactorily. Two new properties recently reached a producing basis in the Moose Creek section of the Matanuska field. Coal from Suntrana in the Nenana field is giving satisfaction as a domestic fuel. This coal has a lower heating value than the Matanuska coals, but the cheapness with which it can be mined enables it to be placed on the Anchorage market at an attractive price.

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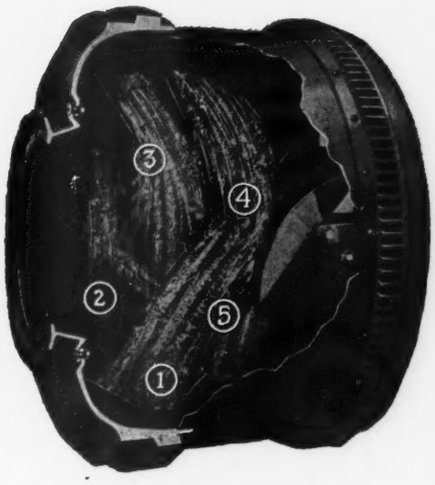
—on what does it depend?



(1) Blade cuts through materials with churning action. (2) Blade carries materials up, spilling down again against motion of drum. (3) Materials hurled across diameter of drum. (4) Materials elevated to drum top and cascaded down to reversed discharge chute which (5) with scattering, spraying action, showers materials back to charging side for repeated trips through mixing process.

THE production of standardized concrete —concrete of absolutely uniform dominant strength—depends on three essentials in addition to the use of proper aggregates.

The first of these — the proper mixing action that prevents separation of aggregate and produces plastic, thoroughly mixed, concrete — is provided by the Koehring five action remixing principle which coats every particle of aggregate thoroughly with cement.

The second factor—the measuring of the proper amount of water to each batch—is under positive control in a Koehring by means of the Koehring automatic water measuring tank. This tank is adjusted to supply the exact amount of water required per batch, and once so regulated, the amount of water is automatically measured for every batch.

The third factor in producing standardized concrete—a means of measuring the thoroughness of mix — is controlled by the Koehring batch meter. This automatically locks the discharge chute as soon as materials enter the drum and holds it so until the specified mixing time for which the meter has been set, has elapsed, when the discharge chute automatically is released and the release signalled by a bell.

"Built to Endure" an artistic booklet of 32 pages beautifully illustrated with etchings, contrasting ancient and modern examples of engineering achievements in concrete, will be sent free upon request to engineering students and others interested.

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THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASS.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY offers courses, each of four years' duration, in Civil, Mechanical and Electrical Engineering; Naval Architecture and Marine Engineering; Mining Engineering and Metallurgy, and Geology and Geological Engineering; Architecture and Architectural Engineering; Chemistry, Chemical Engineering and Electrochemical Engineering; Biology and Public Health, and Sanitary Engineering; Physics, General Science and General Engineering; and in Engineering Administration. These courses lead to the Degree of Bachelor of Science.

To be admitted to the first year class, applicants must have attained the age of seventeen years, and must satisfactorily fulfill entrance requirements in Algebra, Plane and Solid Geometry, Trigonometry, Physics, Chemistry, English, History, and French or German and one elective subject. Examinations are required in all subjects except Chemistry, History and the elective, the requirements for which are fulfilled by the presentation of satisfactory certificates. A division of these entrance subjects between different examination periods is permitted.

Entrance examinations are held at the Institute in September. In June, applicants will be examined by the College Entrance Examination Board in Boston, New York, Philadelphia, Chicago, and many other cities in America and Europe. A circular stating times and places is issued in advance by the College Board.

Graduates of colleges and scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding to at least one year's work at the Institute, are admitted, without examination, to such advanced standing as is warranted by their previous training.

Graduate courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy and Doctor of Science are also offered. Special Research Laboratories of Physical Chemistry, Applied Chemistry and Science have been established.

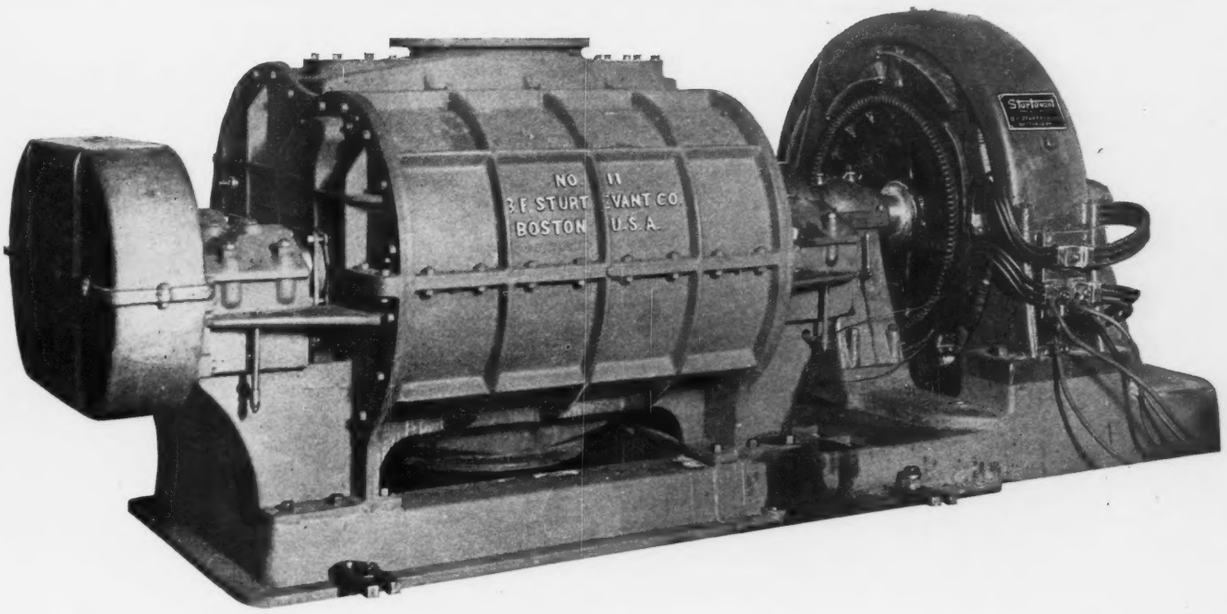
PUBLICATIONS

Bulletins of General Information, Courses of Study, Summer Session, Advanced Study and Research; and the Report of the President and the Treasurer.

Any of the above-named publications will be mailed free on application.

For information, address

ADMISSIONS OFFICE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE 39, Mass.



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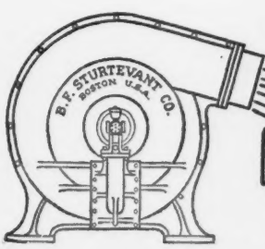

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PORTRAIT OF SIR ISAAC NEWTON

James II is Dead— NEWTON Lives

IT has always been known that free bodies fall. The earth has a strange attraction. How far does it extend? No one knew before Newton, sitting in his garden, one day in 1665, began to speculate.

"Why should not the attraction of gravitation reach as far as the moon?" he asked himself. "And if so, perhaps she is retained in her orbit thereby." He began the calculation, but overwhelmed by the stupendous result that he foresaw, he had to beg a friend to complete it.

In Newton's *Principia* were laid down his famous laws of motion —the basis of all modern engineering. The universe was proved to be a huge mechanism, the parts of which are held together in accordance with the great law of gravitation.

James II was reigning when the *Principia* appeared in 1687. He is remembered for the Bloody Assizes of Jeffreys, for his complete disregard of constitutional liberties, for his secret compacts with Louis XIV and the huge bribes that he took from that monarch, and for the revolution that cost him his crown; Newton is remembered because he created a new world of thought, because he enabled scientists and engineers who came after him to grapple more effectively with the forces of nature.

When, for instance, the Research Laboratories of the General Electric Company determine the stresses set up in a steam turbine by the enormous centrifugal forces generated as the rotor spins, they practically apply Newton's laws in reaching conclusions that are of the utmost value to the designing engineer.

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